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SYNTHESIS OF RESEARCH RESULTS

DREDGED MATERIAL RESEARCH PROGRAM

TECHNICAL REPORT DS-78-23

PUBLICATION INDEX AND RETRIEVAL SYSTEM

April 1980
Final Report

Prepared for
Office, Chief of Engineers, U. S. Army
Washington, D. C. 20314

THE DMRP SYNTHESIS REPORT SERIES

Technical Report No.	Title
DS-78-1	Aquatic Dredged Material Disposal Impacts
DS-78-2	Processes Affecting the Fate of Dredged Material
DS-78-3	Predicting and Monitoring Dredged Material Movement
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The "Publication Index and Retrieval System" is designed to facilitate dissemination of the information contained in the more than 200 reports resulting from the Dredged Material Research Program (DMRP) and to foster operational applications of their findings and conclusions. Information referenced in this document is applicable to project environmental assessments, detailed design, construction, and operation and maintenance as well as evaluation under requirements of regulatory functions programs.

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20. ABSTRACT (Continued)

Chapter 1 contains abstracts of the DMRP Synthesis Reports, which present summaries of findings for each of the major DMRP objectives with emphasis on the significance and application of the information. Chapters 2-9 contain abstracts for each of the detailed reports; the abstracts are identified under the major DMRP objectives. Chapter 10 contains the abstracts of the reports on the field tests and demonstration projects concerned with the effects of dredged material disposal in open water and the use of dredged material for habitat creation.

The abstracts are also indexed as follows: subject, geographic location, agency/organization, and author.

PREFACE

The preparation of this report was authorized by the U. S. Army Engineer Waterways Experiment Station (WES), Dredged Material Research Program (DMRP), and was sponsored by the Office, Chief of Engineers. The objective was to develop an information index and retrieval system for the publications of the DMRP.

The report was prepared by Herner & Company, Washington, D. C., under WES Contract DACW39-77-C-0081. Messrs. E. I. Kelly and N. H. Parkes III of Herner & Company managed the contract.

Development of the system and preparation and review of the report were under the supervision of Dr. R. T. Saucier, Special Assistant for Dredged Material Research, WES, and the general supervision of Dr. John Harrison, Chief of the Environmental Laboratory, WES. The report was reviewed by the DMRP Project Managers: Drs. R. M. Engler and H. K. Smith and Messrs. C. C. Calhoun, Jr., and T. R. Patin.

Directors of WES during preparation of the report were COL J. L. Cannon, CE, and COL N. P. Conover, CE. Technical Director was Mr. F. R. Brown.

CONTENTS

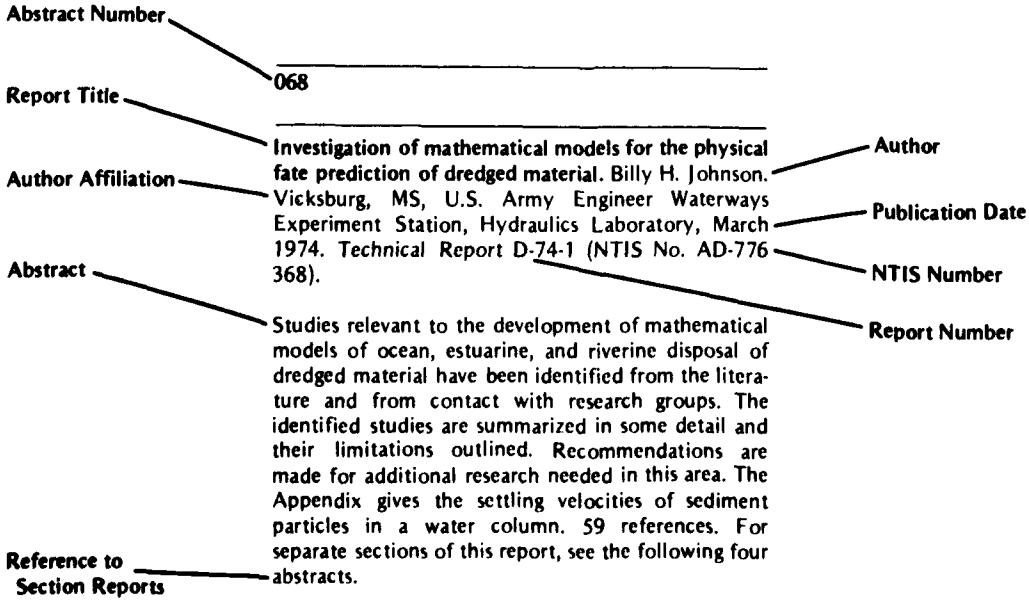
INTRODUCTION

This document, "Publication Index and Retrieval System," is intended to further disseminate the information contained in the more than 200 reports resulting from the U.S. Army Corps of Engineers' Dredged Material Research Program (DMRP) and to foster operational applications of their findings and conclusions. Its style, format, and level of detail are based on findings of a survey of a representative cross-section of scientists and engineers. The potential audience is a very diverse group, including Corps District and Field Office personnel, staffs of other Federal and state agencies, individuals representing environmental/conservation organizations, and scientists and engineers conducting project studies and site monitoring activities. Information referenced in this document is applicable to project environmental assessments, detailed design, construction, and operations and maintenance as well as evaluation under requirements of regulatory functions programs.

The first chapter of this document contains abstracts of DMRP Synthesis Reports. These reports present summaries of findings for each of the major DMRP objectives with emphasis on the significance and application of the information. Chapters 2 through 9 contain abstracts for all significant detailed technical and contractor reports pertaining to the major DMRP objectives. Chapter 10 contains abstracts of the reports on major DMRP field test and demonstration projects concerned with the effects of dredged material disposal in open water and use of dredged material for habitat creation.

Each abstract begins with a citation listing the report title (or title of the section within the report) first, in boldface type. When necessary, a title has been generated and appears within brackets. The rest of the citation lists the personal author(s), corporate author (i.e. the author's organizational affiliation), month and year of publication, report number, and NTIS number, if available.

The abstracts summarize information which has already appeared in DMRP reports; no other judgments or comments have been made. There is one overall abstract for each report, with additional abstracts for significant chapters, sections, and subsections of reports. The abstracts have been constructed to aid the reader in determining the usefulness of consulting the entire report (or section) rather than a means of presenting technical information or conclusions in summary form.



Four indexes follow the abstracting section: Subject Index, Geographic Index, Agency/Organizational Index, and Author Index. Each index entry consists of an index term followed by the title (or annotated title) of the document or document section to which it applies and the abstract number.

CHAPTER 1: SYNTHESIS REPORTS

001

Aquatic dredged material disposal impacts. Synthesis report. *Thomas D. Wright.* Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, August 1978. Technical Report DS-78-1 (NTIS No. AD-A060 250).

The findings of studies of the impact of dredged material disposal in open-water systems (Dredged Material Research Program Task 1A, Aquatic Disposal Field Investigations), conducted at five locations, are summarized. The sites were representative of a variety of disposal practices, dredged materials, and aquatic habitats and included Eatons Neck (New York), Lake Erie (Ohio), Gulf of Mexico (Texas), Columbia River (Oregon), and Duwamish Waterway (Washington). Disposal did not occur during the course of the Eatons Neck investigation but did at the other four sites. In general, there were few significant impacts as a result of disposal. The only physical impacts noted were the creation of mounds of material within the disposal sites and short term turbidity increase in the water column during disposal operations. Following disposal, the mounds were observed to persist for more than a year and to migrate away from the initial point of disposal. There was little evidence of the uptake of chemical substances by organisms. The findings for the studied sites tend to agree with those from complementary studies carried out in the laboratory. 12 references. (Author abstract modified)

002

Processes affecting the fate of dredged material. Synthesis report. Barry W. Holliday. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, August 1978. Technical Report DS-78-2 (NTIS No. AD-A059 276).

The factors and processes affecting the fate of dredged material in subaqueous disposal areas are discussed. Various mechanisms for investigating the stability and fate of dredged material are considered, and a mechanism for determining which parameters and environmental factors should be considered for a specific site is proposed. The report shows how to qualitatively predict the fate of dredged material released in a subaqueous environment, how to determine if sufficient information is available, and how to obtain the necessary data from the field to determine the eventual fate of the mound of dredged material. Examples are presented which serve to describe methods for adequately predicting the fate of a particular dredged material deposit and for helping to anticipate factors which may affect sediment stability. The examples indicate the potential need for field monitoring even when adequate literature is available to document the physical factors present. A basic monitoring design is described which can be used with appropriate additions or modifications at almost all dredged material disposal sites. The results, information, and guidance in this report were derived in part from two Dredged Material Research Program reports entitled 'Assessment of Factors Controlling the Long-Term Fate of Dredged Material Deposited in Unconfined Subaqueous Disposal Areas' (Work Unit 1B04) and 'Field Study of the Effects of Storms on the Stability and Fate of Dredged Material in Subaqueous Disposal Areas' (Work Unit 1B08). 36 references. 29-item bibliography.

003

Predicting and monitoring dredged material movement. Synthesis report. [1]Barry W. Holliday, [2]Billy H. Johnson, [2]William A. Thomas. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, [1]Environmental Laboratory; [2]Hydraulics Laboratory, December 1978. Technical Report DS-78-3 (NTIS No. AD-A063 878).

A summary of the results from three work units (1B06, 1B07, and 1B09) of the Dredged Material Research Program concerned with predicting and monitoring dredged material movement, is presented. Work Unit 1B06 was an evaluation and calibration of the Tetra Tech disposal models using field data collected at several disposal sites, including the Duwamish, New York Bight, and Lake Ontario sites. The collection of these field data was performed under Work Unit 1B09 by Yale University. Work Unit 1B07 involved an evaluation of two two-dimensional finite element models for the long-term prediction of sediment transport in estuaries. The modifications of the Tetra Tech models made by the U.S. Army Engineer Waterways Experiment Station are discussed, and calibration results are presented using field data from the Duwamish, New York Bight, and Lake Ontario disposal sites. A summary of observations from a field data collection program on the

mechanics of the placement of dredged material at open-water disposal sites is provided. The factors involved in the long-term transport of sediment in estuaries, their treatment by finite element models, the limitations of the models, and their current status also are discussed. 12 references. (Author abstract modified)

004

Water quality impacts of aquatic dredged material disposal. (Laboratory investigations.) Synthesis report. *Sterling A. Burks, Robert M. Engler.* Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, August 1978. Technical Report DS-78-4 (NTIS No. AD-A059 735).

The results of the Dredged Material Research Program (DMRP) Environmental Impacts and Criteria Development Project Task 1C, Effects of Dredging and Disposal on Water Quality, are summarized. Selected items of the literature on *sediment and soil-water geochemical interactions were re*viewed for this report in order to provide a background and assessment of the state-of-the-knowledge prior to the DMRP. This review suggested conditions which may enhance release of contaminants from sediments, while there were geochemical conditions which could retard release and render contaminated sediments relatively harmless. DMRP laboratory investigations were carried out to determine the geochemical conditions that maximize and minimize the release of organics, metals, and nutrients from contaminated and noncontaminated dredged material. The report indicates that open-water *disposal of dredged material can have a temporary impact* upon the receiving aqueous environment if the dredged sediments contain elevated levels of chlorinated pesticides, polychlorinated biphenyls, or ammonia. Resedimentation of suspended particles that have sorbed any of these contaminants creates a potential for impact upon benthic organisms. Most of the results reviewed in this report were concerned with short-term effects of constitutents associated with sediments. A summary of experimental designs, methodologies, and analytical methods employed in the DMRP Task 1C research investigations is appended for general information. *40 references.*

005

Effects of dredging and disposal on aquatic organisms. Synthesis report. Nina D. Hirsch, Louis H. DiSalvo, Richard K. Peddicord. Oakland, CA, University of California, Naval Biosciences Laboratory, August 1978 Technical Report DS-78-5 (NTIS No. AD-A058 989).

Data from the U.S. Army Corps of Engineers' Dredged Material Research Program, Task 1D, which investigated the *direct and indirect effects of dredging and disposal of* dredged material on aquatic organisms, are summarized. Determination of potential environmental effects of dredging and disposal is still in preliminary stages, despite research conducted to date, due to the many variables involved. Direct *effects of dredging and disposal are restricted to the immedi*ate area of operation. They include removal of organisms at dredging sites and burial of organisms at disposal sites. Data indicate that the recovery of disturbed sites occurs over periods of weeks, months, or years depending on the type of environment. Most organisms studied were relatively insensitive to the effects of sediment suspensions in the water. Dredging-induced turbidity is probably not of major environmental concern in most cases, but may be an aesthetic problem. Bioavailability of sediment-sorbed heavy metals is low, the release of sediment-associated heavy metals and their uptake into organism tissues being found to be the exception rather than the rule. The diversity of variables that have the potential for direct and indirect effects on aquatic life argues for an integrated, whole-sediment bioassay, using sensitive test organisms. Such a procedure is under development by the Environmental Protection Agency and the Corps of Engineers and should uncover site-specific toxicity problems which can be addressed by appropriate chemical testing and biological evaluation of dredged material. 35 references. (Author abstract)

006

Evaluation of dredged material pollution potential. Synthesis report. James M. Brannon. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, August 1978. Technical Report DS-78-6 (NTIS No. AD-A059 724).

Data are summarized from the U.S. Army Engineer Waterways Experiment Station Dredged Material Research Program, Task 1E, which investigated the pollution properties of dredged material and procedures for determining their potential for effect on water quality and aquatic organisms. The short-term impact of dredged material on water quality and aquatic organisms is related to the concentration of chemically mobile, readily available contaminants rather than to the total concentration. The Elutriate Test, which measures concentrations of contaminants released from dredged material, can be used to evaluate short-term impacts on water quality. Longer term impacts have generally been slight and can be evaluated by means of the Elutriate Test and analysis of the mobile forms of sediment contaminants. No significant long-term increase in water column contaminant concentrations has been observed at any aquatic disposal field site. The greatest potential hazard of dredged material disposal is the effect of the material on benthic organisms. Most dredged material has not proven particularly toxic, but some dredged material can be extremely toxic or of unknown toxicological character. Benthic bioassay procedures are available which can identify this toxic dredged material. A discussion of the chronology of regulatory criteria development and the currently required regulatory testing procedures and their impact is included. 36 references. (Author abstract modified)

007

Confined disposal area effluent and leachate control. (Laboratory and field investigations.) Synthesis report. [1]Kenneth Y. Chen, [1]James L. Mang, [1]Bert Eichenberger, [2]Ronald E. Hoeppel. [1]Los Angeles, CA, University of Southern California; [2]Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, October 1978. Technical Report DS-78-7 (NTIS No. AD-062 882).

The findings of five Dredged Material Research Program Environmental Impacts and Criteria Development Project Task 2D work units concerned with the impact of dredged material disposal in confined land disposal areas are summarized. Three of the work units dealt with active disposal operations at 11 sites; impact was assessed by comparing the quality of influents and effluents at each site with background surface receiving water. Two work units evaluated the impact of confined disposal area leachates on groundwaters. Data from the active disposal studies show that in most cases soluble concentrations of most chemical constituents were very low. Only soluble manganese and ammonia nitrogen levels failed to meet most criteria. The concentrations of chlorinated hydrocarbons, most trace metals, and total phosphorus in unfiltered effluent water also failed to meet most water quality criteria. Thus, it appears that efficient removal of suspended solids before effluent discharge is necessary to meet these regulatory constraints. The leachate studies suggest that the disposal of brackish water dredged material in upland disposal areas may render subsurface water unsuitable for public water supply or irrigation purposes. It is recommended that guidelines for evaluation of potential upland disposal sites be developed in a stepwise progression that will not require complete execution of the total program to assess site suitability. Seven items which may be included in a site-specific evaluation are discussed. 9 references. (Author abstract modified)

008

Disposal alternatives for contaminated dredged material as a management tool to minimize adverse environmental effects. Synthesis report. R. P. Gambrell, R. A. Khalid, W. H. Patrick, Jr. Baton Rouge, LA, Louisiana State University, Center for Wetland Resources, December 1978. Technical Report DS-78-8.

A guidelines manual for selecting and managing disposal methods for contaminated dredged sediments to minimize adverse environmental effects is presented. To accomplish this objective, the report includes a synthesis of published research findings on the chemical mobility of sediment-bound contaminants under various conditions of dredged material disposal. The factors which should be evaluated to determine the environmental acceptability of a proposed disposal method for a contaminated sediment are examined. A brief review of the chemistry of contaminants in sediment-water systems, the properties of the dredged sediment that affect the fate of contaminants, and the short-term and long-term physicochemical (acidity, oxidation-reduction conditions, and salinity) environments of the dredged material at the disposal site which influence processes enhancing or retarding contaminant mobility is included. Management practices which may be used to improve a marginally acceptable disposal method, especially where environmentally optimum methods are not feasible for technological or economic reasons, also are discussed. 114 references.

009

Assessment of low-ground-pressure equipment for use in containment area operation and maintenance. Synthesis report. William E. Willoughby. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, July 1978. Technical Report DS-78-9 (NTIS No. AD-A058 501).

Guidelines for the selection of equipment to operate in and around confined disposal areas are presented. The report is a synthesis of three studies, conducted as part of the Dredged Material Research Program, Task 2C, involving (1) compilation of a catalog of low-ground-pressure equipment, (2) analytical prediction of vehicle performance, and (3) verification of the predictions of the field condition. Based on the disposal area and vehicle characterizations, a particular piece of equipment can be selected for given working conditions, or the limiting soil strength can be determined for a specific piece of equipment. Examples of the use of the selection methodology for a disposal area for fine-grained material also are presented. Appendices to this report contain (1) the equipment catalog and (2) guidance for performing required soils tests. 3 references.

010

Guidelines for designing, operating, and managing dredged material containment areas. Synthesis report. Michael R. Palermo, Raymond L. Montgomery, Marian E. Poindexter. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, December 1978. Technical Report DS-78-10.

Dredged Material Research Program results pertinent to designing, operating, and managing dredged material confined disposal areas to meet required effluent solids standards and to provide adequate storage volume are summarized. The guidelines are equally applicable to design of new confined disposal areas and to evaluation of existing sites. Field investigations necessary to provide data for confined disposal area design are described to include channel sediment investigations and foundation investigations at the area. Sample type and location, sampling equipment, and sample preservation techniques are included. Laboratory testing procedures required to obtain data for sediment characterization, disposal area design, and estimates of long-term storage capacity are given, and procedures are described for confined disposal area design for retention of suspended solids based on solids removal through gravity sedimentation. Guidelines for estimation of gains in long-term

storage capacity due to settlements within the confined disposal area are presented. Design and operational procedures for weirs are presented based on the assumption that the capability for selective withdrawal of the clarified upper layer of ponded water will be provided. Confined disposal area management activities are described which may be considered as possibilities for improving efficiency and prolonging the service life of confined disposal areas. Appendices to this report present: (1) detailed test procedures; (2) a summary of design data requirements; (3) example design calculations; and (4) summaries of research pertinent to designing, operating, and managing dredged material confined disposal areas. 34 references. (Author abstract modified)

011

Guidelines for dewatering/densifying confined dredged material. Synthesis report. T. Allan Haliburton. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, September 1978. Technical Report DS-78-11 (NTIS No. AD-A060 405).

The results of Dredged Material Research Program Disposal Operations Project Task 5A, Dredged Material Densification, are presented in the form of guidelines for dewatering by progressive trenching, dewatering by underdrainage, and for confined disposal area operation and management to facilitate dewatering. Based on the results of research, it has been determined that: (1) use of progressive surface trenching concepts to remove disposal area ponded surface water and precipitation and enhance evaporative dewatering of fine-grained dredged material is the most cost-effective dewatering alternative; (2) when existing conditions make it impossible to implement a surface trenching dewatering program, a surface trenching program alone will not produce dewatering at necessary rates, or when it is desired to obtain maximum possible dewatering effects, various concepts of either gravity-assisted or vacuum-assisted underdrainage may be applied; and (3) implementation of any program of fine-grained dredged material dewatering and densification will be conducted most effectively as part of an overall confined disposal area management plan. The main technical unknown in application of concepts synthesized in the report is the exact rate at which dewatering will occur. State-of-the-art prediction methods given and referenced in the report are satisfactory for feasibility determinations and, in many instances, for use in final design. Monthly standard Class A Pan evaporation data for the continental United States are given in the Appendix. 20 references. (Author abstract modified)

012

Guidelines for disposal area reuse. Synthesis report. Raymond L. Montgomery, Alfred W. Ford, Marian E. Poindexter, Michael J. Bartos. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, February 1979. Technical Report DS-78-12.

Disposal area reuse management (DARM) guidelines developed under the Dredged Material Research Program (DMRP) Disposal Operations Project Task 5C are presented. The guidance is intended to: (1) describe the concept of disposal area reuse and show the role of disposal area reuse in the long-range planning of dredged material disposal; (2) aid in determining the feasibility of developing reusable disposal areas, either new areas or existing ones converted for reuse; and (3) aid in the preparation of designs for reusable disposal areas. The guidance includes the identification of pertinent legal, environmental, and technological factors which influence the planning and selection of reusable sites. The DARM techniques have been tried periodically by Corps of Engineers Districts across the United States and have met with varying degrees of success. Brief descriptions of applications in the Mobile, Sacramento, Philadelphia, Norfolk, Charleston, Savannah, and Galveston Districts are provided. Appendices to this report present (1) summaries of pertinent research conducted by DMRP for reusing and managing dredged material disposal areas (Contract Reports D-74-6, D-74-2, and D-74-7 and Technical Reports D-77-18, D-78-22, D-78-5, D-77-32, D-78-27, and D-78-56) and (2) summaries of six reports on disposal area reuse management (Miscellaneous Paper D-76-16, a Technical Report in preparation, Technical Reports D-77-19, DS-78-11, and D-78-10, and Contract Report D-75-5). 33 references. (Author abstract modified)

013

Prediction and control of dredged material dispersion around dredging and open-water pipeline disposal operations. Synthesis report. William D. Barnard. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, August 1978. Technical Report DS-78-13 (NTIS No. AD-A059 573).

The laboratory and field results of eight separate, but related, contract research studies performed within Task 6C of the Dredged Material Research Program are synthesized, and the available literature concerned with turbidity generation by different types of dredging operations is summarized. Water-column turbidity generated by dredging operations is usually restricted to the vicinity of the operation and decreases rapidly with increasing distance from the operation due to settling and horizontal dispersion of the suspended material. Turbidity levels around dredging operations can be reduced by improving existing cutterhead dredging equipment and operational techniques, using watertight buckets, and eliminating hopper dredge overflow or using a submerged overflow system. During open-water pipeline disposal of fine-grained dredged material slurry, 97-99 percent of the material descends rapidly to the bottom of the disposal area where it forms a low gradient fluid mud mound. One to three percent of the discharged slurry will remain suspended in the water column in the form of a turbidity plume. The relative degree of dredged material dispersion at open-water pipeline disposal operations can be controlled best by using different discharge configurations. By implementing the guidelines given in this report for selecting dredges, improving operational techniques, properly using silt curtains, and selecting appropriate pipeline discharge configurations, dredging or disposal oper-

ations can be conditioned to minimize environmental impacts. The Appendix to this report describes the relationship of suspended solids concentration, bulk density, and percent solids by weight. 70 references. (Author abstract modified)

014

Treatment of contaminated dredged material. Synthesis report. William D. Barnard, Terry D. Hand. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, June 1978. Technical Report DS-78-14.

The results of seven research studies performed within Task 6B, Treatment of Contaminated Dredged Material, of the Dredged Material Research Program Disposal Operations Project are synthesized. The report examines, in the context of both open-water and confined disposal, processes and techniques for treating dredged material or the effluent from confined areas to minimize the impact on receiving waters. Although generalizations are difficult to make, several findings have emerged from the various studies. For confined disposal operations, it has been concluded that: (1) sedimentation in a confined disposal area should be regarded as the primary treatment of the dredged material; (2) existing areas will function more efficiently as settling basins through dredge size reduction, intermittent pumping, increasing the weir length, and increasing the ponding depth by raising the weir; and (3) organic polymer flocculants can be used effectively to coagulate and clarify effluents from confined disposal areas containing unacceptably high solids concentrations. For open-water disposal operations, the following finding is emphasized: saturation of the slurry carrier water with dissolved oxygen accomplished through injection of oxygen into the pipeline can marginally reduce the depression in dissolved oxygen levels in the water column, but oxygenation of the slurry, using air injection, and injection of chemical oxidants, is not recommended. 27 references.

015

Upland and wetland habitat development with dredged material: ecological considerations. Synthesis report. John D. Lunz, Robert J. Diaz, Richard A. Cole. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, November 1978. Technical Report DS-78-15 (NTIS No. AD-A067 828).

Guidance on providing an ecological framework is presented for environmental planners and managers considering the habitat development option of dredged material disposal. The report was prepared as part of the Dredged Material Research Program under the Habitat Development Project Tasks 4A and 4B. The report (1) identifies the historical precedences for habitat development, (2) describes an ecological management philosophy relevant to habitat development decisions, (3) summarizes briefly current ecological theories and observations on natural plant-habitat and animal-habitat interactions, (4) presents some general design considerations for habitat development, and (5) considers special conditions (habitat displacement and chemical mobilization) that modify dredged material disposal operations designed for habitat development. The four types of habitats discussed are: upland mainlands and peninsulas, upland islands, wetlands, and aquatic habitats. 63 references.

016

Wetland habitat development with dredged material: engineering and plant propagation. Synthesis report. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, December 1978. Technical Report DS-78-16.

Pertinent literature and research of the Dredged Material Research Program (DMRP) including six major marsh development field sites are synthesized. These sites are: Windmill Point in the James River, Virginia; Buttermilk Sound on the coast of Georgia; Bolivar Peninsula in Galveston Bay, Texas; Miller Sands, Columbia River, Oregon; Drake Wilson Island in Apalachicola Bay, Florida; and Salt Pond No. 3, South San Francisco Bay, California. Guidelines for developing marsh habitat are presented: (a) planning the project in relation to the proposed site and project goals; (b) engineering construction of the site including dredging operations; (c) propagation, maintenance, and monitoring of the site as habitat, including potential problems that may be encountered; and (d) costs. Emphasis is is placed on engineering and plant propagation. Engineering aspects and design of potential sites are discussed and include protective and retention structures, substrate and foundation characteristics, dredging operations, and elevation and drainage requirements. Phases of plant propagation are detailed in the text and tables: selecting plant species for the site, collecting and storing plant materials, selecting a propagule type, planting the site, maintaining and monitoring the site, pilot studies, costing the work, and allowing natural colonization. Tables of 115 selected plant species showing best propagules; occurrence by region and whether now occurring on dredged material; growth requirements; propagule handling methods; soil, salinity, and inundation tolerances; and other pertinent information are given. Apendices to this report contain: (1) a listing of DMRP reports pertinent to marsh development; (2) common and scientific names of plants and animals mentioned in the text, appendices, and tables; and (3) a synopsis of 28 plant species discussing their characteristics, value, and potential use on dredged material. 117 references. (Author abstract modified)

017

Upland habitat development with dredged material: engineering and plant propagation. Synthesis report. L. Jean Hunt, Alfred W. Ford, Mary C. Landin, B. R. Wells. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, December 1978 Technical Report DS-78-17

Pertinent literature and research on upland habitat development conducted by the Habitat Development Project, Task 4B

of the Dredged Material Research Program, are synthesized. Field sites were located at Nott Island in the Connecticut River (Connecticut), Bolivar Peninsula in Galveston Bay (Texas), and Miller Sands in the Columbia River (Oregon). Guidelines for developing existing or potential dredged material disposal sites into upland habitat are presented. They involve: (1) planning and designing the project in relation to the proposed site and project goals; (2) constructing the site, including dredging and disposal operations, substrate modification, and vegetation establishment; (3) maintenance and management of the site as a habitat; (4) costs of proposed and sample projects; and (5) potential problems. Emphasis is placed on engineering and plant propagation. Engineering aspects include data collection and analysis for site design, protective and retention structures, substrate characteristics, dredging and disposal operations, and specific requirements. The phases of plant propagation include: selecting plant species; selecting, collecting, and handling plant materials; planting; maintenance and management; and cost estimates. Tables of 360 selected plant species are given which show best propagules, occurrence by region and whether known to occur on dredged material, growth requirements and habits, propagule handling methods, soil tolerances, and other pertinent information. Appendices to this report give: (1) a partial listing of commercial soil testing facilities; (2) common and scientific names of animals and plants mentioned in the text and tables; and (3) sources of plant propagules. 165 references. (Author abstract modified)

018

Development and management of avian habitat on dredged material islands. Synthesis report. Robert F. Soots, Jr., Mary C. Landin. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, September 1978. Technical Report DS-78-18 (NTIS No. AD-A066 802).

As part of the Dredged Material Research Program Island Habitat Development Project Task 4F, seven regional studies were conducted throughout Corps of Engineers-maintained waterways to determine dredged material island use by nesting waterbirds and the succession of vegetation on these islands as affected by bird use, to compare diked and undiked islands and natural and man-made islands and sites, and to study migratory and year-round use of dredged material islands. These data and pertinent management information are synthesized in this report. Recommendations and guidelines for management of existing dredged material islands and creation of new islands are presented. Five major factors determining selection for waterbird colony sites on dredged material islands are set forth: isolation from predators and humans, habitat diversity, nesting substrate stability, species behavioral characteristics, and species feeding and foraging habits. Management for waterbird colonies has been proven feasible and may be accomplished through: incorporation of management plans into routine dredging operations, interagency and intraagency cooperation, and public education and cooperation. It was determined that dredged material islands often are crucial habitat for colonial waterbirds and should be maintained and managed as such. Appendices to this report present: (1) scientific and common names of flora and fauna mentioned in the text; (2) a bibliography of pertinent research on colonial waterbirds and their management; and (3) an example of a management plan. 60 references. (Author abstract)

019

An introduction to habitat development on dredged material. Synthesis report. Hanley K. Smith. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, December 1978. Technical Report DS-78-19 (NTIS No. AD-A067 202).

An overview of the dredged material disposal alternatives involving habitat development is presented based on work performed as part of the Dredged Material Research Program (DMRP) Habitat Development Project Tasks 2A, 4A, 4B, 4E, and 4F. Four general habitat types are suitable for establishment on dredged material: marsh, upland, island, and aquatic. Conditions favoring habitat development are described, and a general habitat selection procedure is outlined. The rest of the report deals with more specific aspects of marsh, upland, island, and aquatic development. The advantages and disadvantages of each alternative are considered, and procedural guidelines are provided. Factors considered include characterization of the dredged material, site selection, engineering, cost of alternatives, sociopolitical implications, and environmental impacts. Techniques for actual construction and development of a specific habitat are not discussed. A selected bibliography of DMRP reports pertinent to habitat development is appended.

020

Productive land use of dredged material containment areas: planning and implementation considerations. Synthesis report. Michael R. Walsh, Mark D. Malkasian. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, September 1978. Technical Report DS-78-20.

General guidance is provided for planning and implementing the land use of dredged material confined disposal areas, based on research conducted within Task 5D of the Productive Uses Project of the Dredged Material Research Program. Seven productive land use categories are defined based on functional use: recreational (commercial and noncommercial), industrial/commercial (including port development and residential use), agricultural (including horticulture and mariculture), institutional (including public transportation), material transfer, waterway-related, and multiple purpose. Engineering, environmental, socioeconomic, and legal and institutional considerations that are important with regard to disposal-productive land use projects are reviewed. A land value methodology is included which provides estimates of (1) the direct market value of the created land and (2) related community benefits and adverse impacts from the productive land use. Planning and implementation factors for disposal-

productive use projects are examined, and policy and planning issues affecting the land use of dredged material confined disposal areas are discussed. Appendices to this report present (1) Task 5D research report abstracts and (2) an example of State law matrix. 47 references.

021

Guidance for land improvement using dredged material. Synthesis report. Patricia A. Spaine, Jose L. Llopis, Eugene R. Perrier. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, November 1978. Technical Report DS-78-21 (NTIS No. AD-A067 195).

Concepts and guidelines for planning and implementing land improvement projects using dredged material are provided. The report synthesizes research conducted as part of Tasks 3B and 4C of the Dredged Material Research Program (DMRP); it was written as part of the Productive Uses Project. Information is drawn from DMRP research reports, literature surveys, field demonstrations, and greenhouse studies. Environmental, technical, economic, social, and legal aspects of projects are presented as well as outlines of project planning procedures and dredged material transport systems. Three dredged material land improvement techniques are detailed: surface mine reclamation, sanitary landfill, and agricultural use. Planning, construction, and equipment considerations are presented for each technique. Local, State, and Federal government sources which have jurisdiction or expertise in the various aspects of land improvement projects are included. The report describes techniques for land improvement which utilize dredged material productively as alternatives to conventional disposal methods in regions where land acquisition is difficult and open-water disposal infeasible. The Appendices provide: (1) summaries of research conducted under Tasks 3B and 4C plus other research pertinent to this study; (2) the Interim Report on Surface Mine Reclamation Demonstration; and (3) three tables on potential vegetative covers for land improvement projects using dredged material. 46 references. (Author abstract)

CHAPTER 2: EFFECTS OF DREDGING OPERATIONS ON WATER QUALITY AND AQUATIC ORGANISMS

Effects of Dredging and Disposal on Water Quality

022

Disposal of dredge spoil: problem identification and assessment and research program development. M. B. Boyd, R. T. Saucier, John W. Keeley, Raymond L. Montgomery, R. D. Brown, David B. Mathis, C. J. Guice. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, November 1972. Technical Report H-72-8 (NTIS No. AD-757 599).

The Corps of Engineers, in fulfilling its mission in developing and maintaining the nation's navigable waterways, is responsible for extensive dredging operations. Considerable concern has developed as to the environmental impact of the operations, with particular emphasis on open water disposal, especially of spoil materials containing pollutants. The Corps of Engineers was authorized by Congress in the 1970 River and Harbor Act to initiate a comprehensive nationwide study to provide information on the environmental impact of dredging and dredge spoil practices. The study was divided into four phases: (1) problem identification and assessment, (2) development of research program, (3) accomplishment of needed research, and (4) field evaluation of new and improved disposal practices. This report gives the results of the problem assessment phase of the study and outlines the recommended research program. The Appendix lists ongoing research projects. 96 references. (Author abstract modified).

023

Open water disposal. In: *Disposal of dredge spoil: problem identification and assessment and research program development,* pp. 35-55. November 1972. Technical Report H-72-8.

Estimates are given of the average annual amounts of new and maintenance dredged material disposed of in open water, together with estimates of average annual amounts of different types of spoil. The relative usage and operating practices of pipeline, hopper, sidecaster, dipper, clamshell, and bucket dredges are discussed in relation to open water disposal. Finally, the literature on the environmental impacts of open water dredging and disposal is reviewed. For an overall summary of Technical Report H-72-8, see abstract no. 22.

024

Laboratory study of the release of pesticide and PCB materials to the water column during dredging and disposal operations. Richard Fulk, David Gruber, Richard Wullschleger. Milwaukee, WI, Envirex Inc., Environmental Sciences Division, December 1975. Contract Report D-75-6 (NTIS No. AD-026 685).

A study of the type and concentration of pesticide materials in sediments subject to dredging and of the transfer of these materials to the water column during dredging or disposal operations is described. Areas sampled were: Calumet Harbor in Chicago, Illinois; Green Bay near the mouth of the Fox River near Green Bay, Wisconsin; Mt. Hope Bay near Fall River, Massachusetts; Tabbs Bay near the Houston Ship Channel, Texas; and Tennessee Chute, the channel connecting the Mississippi River and Memphis Harbor at Memphis, Tennessee. The discussion of results covers: sediment characteristics, water column water characteristics, interfacial water characteristics, and migration test and settling test findings. Appendices to the report include: (1) common and chemical names of chlorinated hydrocarbons used in the report; (2) analytical procedures; (3) results of preliminary work in Milwaukee Harbor; and (4) water temperatures and dissolved oxygen measurements taken during sampling of sediments. 25 references.

025

Research study on the effect of dispersion, settling, and resedimentation on migration of chemical constituents during open-water disposal of dredged materials. Kenneth Y. Chen, Shailendra K. Gupta, Amancio Z. Sycip, James C. S. Lu, Miroslav Knezevic, Won-Wook Choi. Los Angeles, CA, University of Southern California, Environmental Engineering Program, February 1976. Contract Report D-76-1 (NTIS No. AD-A022 144).

An extensive laboratory investigation of the effect of dispersion, settling, and resedimentation on migration of chemical constituents during open-water disposal of dredged materials is described following a brief review of the literature. The study shows that concerns regarding the release of any significant quantity of toxic materials into solution phase are

unfounded. However, it is indicated that trace metals and chlorinated hydrocarbons associated with macromolecular organics and suspended particles released to the water column as a result of dredging may have some unknown effect. The results of an investigation of the chemistry of chlorinated hydrocarbons and organo-metallic complexes as related to their bioavailability are also presented. Fifty-five tables and 43 figures are included. 155 references. (Author abstract modified)

026

Effect of sediment organic matter on migration of various chemical constituents during disposal of dredged material. B. E. Blom, T. F. Jenkins, D. C. Leggett, R. P. Murrmann. Hanover, NH, U.S. Army Cold Regions Research and Engineering Laboratory, May 1976. Contract Report D-76-7 (NTIS No. AD-A027 394).

Laboratory studies were conducted to evaluate the direct and indirect effects of sediment organic fractions on the migration of various chemical constituents during aquatic disposal of dredged materials. A literature review also was conducted to determine specifically the physical/chemical nature of sediment organic matter and metal-organic interactions. Three different sediments from New York Harbor and the Great Lakes Region were evaluated in seawater and freshwater. In addition, Great Lakes sediments were placed in seawater to evaluate the effect of disposal site water salinity on less brackish sediments. Long-term studies examined the possibility of transport of material from sediments into an overlying water column and monitored the changes in the aqueous phase which initially contained large amounts of suspended matter. Specific components migrating from the sediment into the water column include ammonium-nitrogen, orthophosphate, cadmium, and manganese, the latter only in seawater media. Organic carbon and inorganic nitrogen underwent transformation with the systems investigated. Both sediment organic carbon and soluble organic matter were generally found to have no demonstrable effect on water quality with the exception of two sediments containing significant amounts of petroleum hydrocarbons. Appendices to this report describe (1) additional analytical data and (2) particle size analysis and mineral identification. 109 references. For a separate section of the report, see the following abstract.

027

[Organics in natural water systems and organo-metallic complexes in natural water systems; review of literature.] In: *Effect of sediment organic matter on migration of various chemical constituents during disposal of dredged material,* pp. 5-23. May 1976. Contract Report D-76-7.

A review of the literature on the physical/chemical nature of sediment organic matter and metal-organic interactions in natural water systems is presented. The types of soluble organic compounds identified in natural waters are reviewed briefly; they include fulvic acids (and their parent humic acids), which are groups of naturally occurring polymeric molecules containing carbonyl, hydroxyl, and carboxylic acid functional groups capable of interacting with metals. Nonhumic substances covered are proteins, enzymes, and amino acids, such as leucine, which are capable of complexing metals. The role of metal-organic complexes is discussed, and analytical techniques for characterizing them, such as gel permeation chromatography and anodic stripping voltammetry, are described. For an overall summary of Contract Report D-76-7, see abstract no. 26.

028

Transformations of heavy metals and plant nutrients in dredged sediments as affected by oxidation reduction potential and pH. Volume I: Literature review. R. A. Khalid, R. P. Gambrell, M. G. Verloo, W. H. Patrick, Jr. Baton Rouge, LA, Louisiana Agricultural Experiment Station, Louisiana State University, May 1977. Contract Report D-77-4 (NTIS No. AD-A041 468).

Literature on the occurrence and chemistry of selected trace metals and plant nutrients in sediment-water systems is discussed. The effects of pH and oxidation-reduction conditions on metal and nutrient chemistry are emphasized where this information is available. The toxic and nutrient elements included are lead, cadmium, mercury, arsenic, selenium, copper, zinc, manganese, iron, nitrogen, phosphorus, and sulfur. The scope and limitations of various selective chemical fractionation procedures developed to determine the chemical forms of trace metals and nutrients in soil and sediment-water systems also are reviewed. This review determined that many laboratory studies simulating the transport of reduced sediments to an oxygenated environment have reported some release of toxic metals and biostimulants and others have shown no release of many elements. However, too few studies (at the time of these investigations) of actual dredging and dredged material disposal operations have been completed to draw broadly applicable conclusions regarding the effects of dredging on water quality. 414 references. (Author abstract modified)

029

Transformations of heavy metals and plant nutrients in dredged sediments as affected by oxidation reduction potential and pH. Volume II: Materials and methods/results and discussion. R. P. Gambrell, R. A. Khalid, M. G. Verloo, W. H. Patrick, Jr. Baton Rouge, LA, Louisiana Agricultural Experiment Station, Louisiana State University, May 1977. Contract Report D-77-4 (NTIS No. AD-A041 469).

Studies on the influence of pH and redox potential on metal chemistry in sediment-water systems are described. One laboratory study was conducted to determine the effects of pH and oxidation-reduction conditions on the distribution of mercury, lead, cadmium, zinc, copper, manganese, iron, phosphorus, and ammonium-nitrogen among selected chemical forms in sediment-water systems from four sites. Another

study was carried out to determine the effects of pH and oxidation-reduction potential on the capacity of the sediment materials to retain high levels of added toxic metals. The effect of dissolved oxygen on the chemical form and distribution of metal ions and nutrient elements in Barataria Bay (coastal Louisiana) sediment suspensions and metal complexation with soluble organics in Barataria Bay sediment material are discussed. Sampling site location maps and data tables are provided in the appendices to the report. 75 references.

030

An assessment of problems associated with evaluating the physical, chemical, and biological impacts of discharging fill material. L. W. Canter, E. H. Klehr, J. W. Laguros, L. E. Streebin, G. D. Miller, D. R. Cornell. Norman, OK, University of Oklahoma, School of Civil Engineering and Environmental Science, December 1977. Technical Report D-77-29 (NTIS No. AD-A052 519).

A multidisciplinary evaluation of difficulties associated with determining environmental changes resulting from fill material discharges is presented. A literature survey was conducted to pinpoint technical deficiencies. A weighted-rankings technique was employed to establish priorities for administrative/procedural and technical problems. While technical information does exist regarding the environmental impacts of various types of fill material used in a number of projects, there are major informational deficiencies relative to impact prediction, assessment, and mitigation. Among other areas, accompanying tables cover the following topics: effects of construction projects on water quality; water pollution from construction activities cause/effect matrix; administrative/procedural problems related to fill material discharge; technical problems and needs related to fill material discharge; and weighted-rankings of technical problems and needs. Appendices to the report contain: (1) a legal and legislative history of Corps dredging; (2) regulations and guidelines relating to requirements for fill discharge; (3) informational contacts; (4) methodologies for environmental impact assessment; (5) case studies on discharging fill materials; (6) information on minimization of environmental impacts; and (7) engineering design considerations for fill material projects. 284 references. For separate sections, see the following two abstracts.

031

Fill material and filling activities: an overview. In: *An assessment of problems associated with evaluating the physical, chemical, and biological impacts of discharging fill material,* pp. 7-21. December 1977. Technical Report D-77-29.

Basic definitions and concepts concerning fill material are discussed, and the magnitude of recent filling activities in the United States is examined. An accompanying table summarizes five categories of fill material discharge (structures and impoundments, site development, causeways/road fills, property protection, pollution control, and other) and corresponding locations and physical configurations. Examples of existing and proposed onshore and offshore fill discharge projects and of man-altered fill materials (dredged material, municipal solid wastes and incinerator residue, coal ash, mine tailings, and various sludges) are presented. For an overall summary of Technical Report D-77-29, see abstract no. 30.

032

Physical, chemical, and biological impacts. In: *An assessment of problems associated with evaluating the physical, chemical, and biological impacts of discharging fill material,* pp. 22-91. December 1977. Technical Report D-77-29.

Overviews of general physical, chemical, and biological impacts of fill discharge activities are presented, and anticipated impacts are examined according to the type of fill material. The usefulness of the Elutriate Test and the bioassay test for identifying anticipated environmental effects from the discharge of fill material is evaluated. The Elutriate Test is a second generation attempt to predict the impacts of dredging operations. More information is needed on the reliability of its results for dredging operations. The bioassay test has many limitations, and extrapolation of test information for impact prediction must be considered carefully. Research is needed to establish appropriate test conditions and develop information on the reliability of bioassay results. For an overall summary of Technical Report D-77-29, see abstract no. 30.

Effects of Dredging and Disposal on Aquatic Organisms

033

Methods of dissolved oxygen budget analysis for assessing effects of dredged material disposal on biological community metabolism. Final report. George M. Hornberger, Mahlon G. Kelly. Charlottesville, VA, University of Virginia, November 1975, Contract Report D-75-3 (NTIS No. AD-A018 340).

Three computer programs for calculating a continuous function (a Fourier series) describing net community productivity in aquatic environments using measurements of dissolved oxygen concentration, temperature, and salinity with a solution to the oxygen mass balance equation were prepared. These pertain to the calculation of (1) temporal variation of net productivity in flowing waters (rivers), (2) depth-averaged net productivity for a standing water body, and (3) depth distribution of net productivity in standing waters. These methods are especially well suited for use with continuous automatic data recording and can be effective in assessing the influence of dredging and disposal on aquatic communities. Appendices to the report contain: the flowing water program, the standing water, depth average program; the standing water, depth

distribution program; and a list of abbreviations used. 19 references. (Author abstract modified)

034

Application of ecosystem modeling methodologies to dredged material research. Ross W. Hall, Howard E. Westerdahl, Rex L. Eley. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Effects Laboratory, June 1976. Technical Report D-76-3 (NTIS No. AD-A027 207).

The applicability of physical and mathematical ecosystem modeling methodologies to environmental problems associated with dredging and disposal operations is examined. The three basic approaches used in environmental physical modeling with varying degrees of success and sophistication are reviewed. These include bioassays, microcosms, and scaled ecosystem models. Four rather arbitrary and indistinct classes of mathematical water-quality and ecological models are discussed; they are dissolved oxygen models, chemical models, phytoplankton models, and ecological models. Ecological problem areas for which existing modeling techniques would be useful or for which model development is recommended are outlined, and the general applicability of physical and mathematical modeling to dredged material studies is evaluated. Specific modeling approaches are advocated for the following research problem areas: (1) colonization and ecological succession; (2) biological productivity; (3) material cycling; (4) artificial establishment techniques for habitat creation; (5) direct smothering of benthic organisms; (6) oxygen budget analysis; and (7) pollution criteria development. A table of ecological problems related to dredged material disposal and applicable modeling approaches is appended. 98 references.

035

A bioassay dilution technique to assess the significance of dredged material disposal. Russell H. Plumb, Jr. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Effects Laboratory, September 1976. Miscellaneous Paper D-76-6 (NTIS No. AD-A030 263).

A laboratory procedure for assessing the potential biological impact of open-water disposal of dredged material is described. The procedure incorporates a serial dilution technique based on dye diffusion studies. This approach is necessary because the effect of a discharge is a function of exposure time and effective exposure concentration, and dredged material perturbations are generally of short duration compared with the time intervals specified in conventional bioassays. The procedure was tested using sediment samples and site water collected from several locations in the Mobile, Alabama Ship Channel. *Dunaliella tertiolecta* was the test organism used to bioassay the standard elutriate. The results demonstrate that stimulatory or inhibitory materials do not affect an algal population significantly when the rate of dilution at an open-water site is considered. 10 references. (Author abstract modified)

036

Assessment and significance of sediment-associated oil and grease in aquatic environments. Louis H. DiSalvo, Harold E. Guard, Nina D. Hirsch, James Ng. Oakland, CA, Naval Supply Center, Naval Biosciences Laboratory, November 1977. Technical Report D-77-26 (NTIS No. AD-A050 044).

An extensive literature review and experimental studies on oil and grease determination in aquatic environments are presented. The literature survey reviews knowledge on the content, levels, fate, effects, and methods of analyzing oil and grease, with particular emphasis on the oil and grease fraction associated with natural or simulated sedimentary materials. The experimental section details preliminary experiments conducted to initiate laboratory evaluation of the potential transfer of oil and grease residues (hydrocarbons) from actual dredged material into tissues of selected test species under simulated environmental conditions. The standard elutriate test (minus filtration step) was used with one sediment sample to determine its performance in relation to sedimentary oil and grease content. Gas chromatography of selected samples provides qualitative results unavailable with the thin-layer method. 173 references. For descriptions of tables in this report, see the following two abstracts.

037

Table 1: Summary of analytical methods for determination of oil and grease. In: *Assessment and significance of sediment-associated oil and grease in aquatic environments*, p. 20. November 1977. Technical Report D-77-26.

Twenty-one different analytical methods for determining oil and grease in water and wastewater are reviewed. Gravimetric, volumetric, instrumental, sampling, and continuous monitoring methods are included. For an overall summary of Technical Report D-77-26, see abstract no. 36.

038

Table 8: Techniques for the determination of petroleum components in sediments. In: *Assessment and significance of sediment-associated oil and grease in aquatic environments*, p. 32. November 1977. Technical Report D-77-26.

Commonly used methods for determining petroleum hydrocarbons are summarized. These techniques include: gravimetry, gas chromatography (with flame ionization and flame photometric detectors), gas chromatography/mass spectrometry, fluorescence emission, mass spectrometry, thin-layer chromatography, ultraviolet absorption, infrared absorption,

and high pressure liquid chromatography. For an overall summary of Technical Report D-77-26, see abstract no. 36.

039

Patterns of succession in benthic infaunal communities following dredging and dredged material disposal in Monterey Bay. John S. Oliver, Peter N. Slattery, Larry W. Hulberg, James W. Nybakken. Moss Landing, CA, Moss Landing Marine Laboratories, California State University Consortium, October 1977. Technical Report D-77-27 (NTIS No. AD-A049 632).

Patterns of benthic community development in sandy bottom marine communities are discussed in relation to the ecological effects of dredged material disposal in Monterey Bay, California. Temporal and spatial variations in community structure are related qualitatively to substrate disturbance caused by wave activity, and the amplitude of natural variations along the depth gradient is compared to the changes caused by experimental dredged material disposal. The impact of offshore, canyon head, and harbor disturbances is considered. Ancillary experiments and various types of samples collected are described in the Appendix. 55 references.

040

Availability of sediment-adsorbed selected pesticides to benthos with particular emphasis on deposit-feeding infauna. M. W. Nathans, T. J. Bechtel. Richmond, CA, LFE Corp., Environmental Analysis Laboratories, November 1977. Technical Report D-77-34 (NTIS No. AD-A055 506).

The availability of sediment-associated chlorinated hydrocarbon pesticides to deposit-feeding infauna was studied using artificially prepared, isotopically labeled sediments and an artificial organic substrate as substitute detritus. There was no measurement of initial DDT body burdens in the test animals collected. The data did not receive adequate statistical treatment, and most discussions should be considered qualitative rather than quantitative. The study demonstrated that a viable pathway exists for the movement of radiolabeled DDT from freshly tagged artificial sediments to benthic organisms, but additional experiments are needed to fully assess the significance of this movement. Appendices contain (1) sediment tagging studies and (2) data tables. 24 references.

041

Impact of fluid mud dredged material on benthic communities of the tidal James River, Virginia. Robert J. Diaz, Donald F. Boesch. Gloucester Point, VA, Virginia Institute of Marine Science, Division of Biological Oceanography, December 1977. Technical Report D-77-45 (NTIS No. AD-050 915).

The results of a pilot study consisting of a field assessment of the effects of fluid mud on tidal freshwater benthic communities at the Windmill Point (James River, Virginia) disposal site are presented. The study was conducted as an adjunct to more extensive studies on the physical properties of fluid mud at several estuarine sites. The disposal operation, acute effects at the James River site, general recovery of the disposal area, effects of fluid mud, and adaptations to substrate instability are discussed. The results indicate that the benthic community, dominated by oligochaetes, chironomid insect larvae, and the Asiatic clam *Corbicula*, was acutely impacted by the disposal. The impact was noted by reductions in the fauna and was proportional to the accumulation of dredged material. Appendices to this report list the species taken at benthic sites and the taxonomic classifications of all benthic species. 36 references. (Author abstract modified)

042

Effects of turbidity and suspended material in aquatic environments. Literature review. [1]Edward M. Stern, [2]William B. Stickle. [1]Stevens Point, WI, University of Wisconsin, Department of Biology; [2]Baton Rouge, LA, Louisiana State University, Department of Zoology and Physiology, June 1978. Technical Report D-78-21 (NTIS No. AD-A056 035).

A review of the environmental effects of turbidity, particularly in relation to dredging, is presented. The literature through 1973, and selected references through 1977, are covered. The discussion centers on definitions, units of measure and methods of measurement, origins of turbidity and suspended material, and effects of turbidity and suspended material in aquatic environments. Selected bibliography of 296 items. For separate sections of this report, see the following two abstracts.

043

Origins of turbidity and suspended material in aquatic environments. In: ***Effects of turbidity and suspended material in aquatic environments. Literature review,*** pp. 24-37. June 1978. Technical Report D-78-21.

The natural processes and human activities resulting in turbidity and suspended material in aquatic environments are reviewed. Topics discussed include: erosion and suspension, resuspension, turbidity maxima, turbidity currents, biological sources, waste discharges, other causes of turbidity, and turbidity-reducing processes. The degree of turbidity produced by each of these factors depends upon the character and concentration of the particles in suspension, as well as the nature of the body of water itself. In aquatic environments, the ability to carry suspended sediments is dependent upon both the current velocity and particle size. Accompanying tables, modified from the literature, summarize: critical transportation velocities for particles of various sizes; suspended sediment discharge to oceans from the coterminous United States; and ocean disposal of waste material by coastal

region. For an overall summary of Technical Report D-78-21, see abstract no. 42.

044

Effects of turbidity and suspended material in aquatic environments. In: *Effects of turbidity and suspended material in aquatic environments. Literature review,* pp. 38-88. June 1978. Technical Report D-78-21.

A review of the literature concerning the effects of turbidity and suspended materials in fluvial, lacustrine, estuarine, and coastal marine environments is presented. Water quality, primary production in aquatic environments, selected phyla of invertebrates, and effects on fish are discussed. The literature indicates that turbidity and suspended solids conditions typically created by most dredging and disposal operations are of short duration and are unlikely to produce severe and irreversible ecological effects; possible exceptions to this generalization are coral reefs and other communities especially sensitive to turbidity. Any possible effects of turbidity and suspended material in aquatic environments may be further minimized by carefully selecting disposal sites, keying operations to seasonal cycles in biological activity, and giving special consideration to areas that serve as nursery grounds. For an overall summary of Technical Report D-78-21, see abstract no. 42

045

Considerations in conducting bioassays. David R. Rosenberger, Edward Long, Raymond Bogardus, Elaine Farbenbloom, Robert Hitch, Susan Hitch. Charleston, IL, WAPORA, Inc., Bioassay Laboratory, June 1978. Technical Report D-78-23 (NTIS No. AD-A057 203).

The various aspects of bioassay procedures are examined. A literature review provides an introductory overview of aquatic bioassays, with emphasis on dredged material bioassay techniques. Species selection is discussed at length. Recommended methods for capturing, handling, and maintaining many plants and animals for use in bioassays are presented. 842 references. For separate sections of this report, see the following three abstracts.

046

Principles of aquatic bioassay. In: *Considerations in conducting bioassays,* pp. 12-35. June 1978. Technical Report D-78-23.

The literature on aquatic bioassay is reviewed. Topics discussed include: history of aquatic toxicity, scope of aquatic bioassay, variability of aquatic bioassay testing, proposed standard procedures, and bioassay equipment. Aquatic bioassays, which were developed from pharmacological drug testing techniques, often encounter complex toxicity problems. Two or more toxic compounds may be acting together or the toxicant concentration may fluctuate. The techniques used in aquatic testing may vary depending on the type of toxicant tested and the environmental parameters, such as temperature or dissolved oxygen, that need to be controlled. Toxicant dosing equipment varies with the type of test species, source of water, and type of toxicant in question. Extensive elaboration of the equipment has led to multiple toxicant delivery systems capable of providing a range of concentrations. The two mostwidely used delivery systems are the serial diluter and proportional diluter. For an overall summary of Technical Report D-78-28, see abstract no. 45.

047

Test organisms. In: *Considerations in conducting bioassays,* pp. 36-62. June 1978. Technical Report D-78-23.

Selection of bioassay test species is discussed. Selection criteria are outlined, and species most commonly and most infrequently used are considered. The criteria for selection of species cited by most authors include the following, not listed in order of importance: type of test; economic importance; ecological significance; geographical distribution; ease of capturing, handling, holding, and culturing; availability and local abundance; toxicity responsiveness; consistency of response to toxicity; and reproductive success under assay conditions. Test species which (1) were previously used in turbidity bioassays, (2) present special problems, and (3) are unsuitable for bioassays are mentioned. Recommendations are made for capturing, handling, and maintaining wild-caught organisms and for culture of test organisms and stock populations. Recommended test species also are listed. For an overall summary of Technical Report D-78-23, see abstract no. 45

048

Dredged material bioassay development. In: *Considerations in conducting bioassays,* pp. 63-68. June 1978. Technical Report D-78-23.

The history of bioassay studies conducted with dredged material is reviewed. Such studies have been limited in number and scope. Benthic bioassays with dredged material have been even more limited than water-column bioassays. Water-column impacts have been minor. In contrast, bioassay results suggest that dredged sediments can, under certain circumstances, adversely affect benthic and epibenthic organisms which survive burial during the disposal operation or recolonize the site after disposal operations cease. For an overall summary of Technical Report D-78-23, see abstract no. 45.

049

Effects of suspended dredged material on aquatic animals. Richard K. Peddicord, Victor A. McFarland. Bodega Bay, CA, University of California, Bodega Marine Laboratory, July 1978. Technical Report D-78-29 (NTIS No. AD-A058 489).

Laboratory studies were conducted to evaluate the impact of suspensions of relatively uncontaminated and contaminated harbor and river sediments on juvenile and adult marine, estuarine, and freshwater fish and invertebrates. Studies of survival and tissue accumulation of contaminants were conducted for 21 days' exposure to suspended sediments in a flow-through aquarium system. Suspensions of the more highly contaminated sediment were more harmful than uncontaminated sediment. Even so, mortalities occurred only after longer exposures to higher concentrations of suspended sediment than typically occur in the water column during dredging or disposal. Tissue accumulation of contaminants from suspensions of contaminated sediment proved to be the exception rather than the rule. Of 100 species-salinity-contaminant combinations for which uptake was investigated, tissue accumulation was found in less than 25 percent of the cases. In those cases where tissue accumulation did occur, concentrations were only a few times higher than in the corresponding control animal tissues. Appendices to this report describe conditions in freshwater, marine, and estuarine experiments. 54 references. (Author abstract modified)

050

Vertical migration of benthos in simulated dredged material overburdens. Volume I: Marine benthos. D. L. Maurer, R. T. Keck, J. C. Tinsman, W. A. Leathem, C. A. Wethe, M. Huntzinger, C. Lord, T. M. Church. Lewes, DE, University of Delaware, College of Marine Studies, June 1978. Technical Report D-78-35 (NTIS No. AD-A058 725).

The effect of simulated dredged material disposal on the vertical migration ability and survival of benthic invertebrates was investigated. The species included the bivalves, *Mercenaria mercenaria* and *Nucula proxima*; the mud snail, *Ilyanassa obsoleta*; the polychaete worms, *Scoloplos fragilis* and *Nereis succinea*; the amphipod crustacean, *Parahaustorius longimerus*; and the xanthid mud crab, *Neopanope sayi*. Animals were exposed to varied layers of natural sediment in different sizes of plastic cores and larger aquaria. Sediment types ranged from 100 percent sand to 100 percent silt-clay. The discussion emphasizes the influence of sediment type, sediment depth, duration of burial, and temperature on the two basic patterns of burrowing response. The unexpected ability of many of the species tested to migrate vertically and survive successfully in relatively thick deposits of native and exotic sediments also is emphasized. Chemistry data are appended to the report. 63 references.

051

Availability of sediment-adsorbed heavy metals to benthos with particular emphasis on deposit-feeding infauna. Jerry W. Neff, Robert S. Foster, J. Frank Slowey. College Station, TX, Texas A&M Research Foundation, August 1978. Technical Report D-78-42 (NTIS No. AD-A061 152).

Biological laboratory studies were conducted to evaluate the bioavailability of sediment-adsorbed heavy metals to benthic invertebrates. For these studies, five test organisms (*Rangia cuneata*, *Palaemonetes pugio*, *Palaemonetes kadiakensis*, *Neanthes arenaceodentata*, and *Tubifex sp.*) were exposed to metal-enriched natural sediments for periods up to six weeks at different salinities. The test sediments came from Texas City and Corpus Christi, Texas, ship channels and the Ashtabula, Ohio harbor. The accumulation of eight heavy metals (cadmium, chromium, copper, iron, manganese, nickel, lead, and zinc) by all species and of two metals (mercury and vanadium) by selected species was measured. Statistically significant accumulation of metals from sediment was demonstrated only 36 times (26.5%) out of 136 metal-species-sediment test combinations. Variations in bioaccumulation were observed between species, metals, sediments, and salinity. Correlation was not observed between accumulation and specific metal forms as determined by selective chemical extraction of test sediments, and bulk metal analyses of the test sediments also did not correlate with metal bioavailability. Appendices to this report contain: (1) 19 tables showing analysis of variance of heavy metal uptake by five species of benthic invertebrates exposed to three sediments in short-term and long-term tests; (2) a brief outline of the nonsequential extraction procedures used during all or part of this study; and (3) Environmental Protection Agency Region V and VI suggested guidelines for disposal of metal-laden sediments in open waters. 139 references. (Author abstract)

052

Design of a laboratory microcosm for evaluating effects of dredged material disposal on marsh-estuarine ecosystems. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, Ecosystem Research and Simulation Division, August 1978. Technical Report D-78-52 (NTIS No. AD-A058 953).

The use of laboratory microcosms to evaluate environmental effects of dredged material disposal in salt marsh-estuarine systems was assessed. A preliminary design was formulated consisting of three separate compartments--high marsh, tidal creek and creek bank marsh, and estuary, which were interconnected with pumps controlled by a series of timers for simulating tidal cycles. Areas of the various compartments as well as tidal height and exchange were based on data obtained for Barataria Bay, a salt marsh estuary in southern Louisiana. The approach was tested in an experiment designed to compare the nutrient flux and biological community metabolism of a natural salt marsh with a marsh developing on dredged material. For purposes of evaluation, two microcosms were constructed, each containing a salt marsh tank

and a tidally linked estuary tank. Rates of nutrient flux and community metabolism in the microcosms compared favorably with published values from field studies. Final design recommendations are formulated, and the use of microcosms for addressing environmental effects of dredged material disposal is discussed. Marsh-estuarine microcosms appear to be useful for determining effects of engineeering activities and resource management alternatives on many basic ecological functions of salt marsh-estuarine systems. 29 references. (Author abstract modified)

Turbidity and Fluid Mud Prediction and Control

053

Techniques for reducing turbidity associated with present dredging procedures and operations. John W. Huston, William C. Huston. Corpus Christi, TX, John Huston, Inc., May 1976. Contract Report D-76-4 (NTIS No. AD-A026 623).

Operational techniques that can be used with existing technology and equipment to reduce turbidity created by a dredging plant were examined. The study focused primarily on hydraulic dredging. Attention was paid to the cost and ease of implementation as well as to the effect on dredge operation and production rate. Techniques for reducing turbidity fall into the categories of the cutter, ladder, suction, hull, pipeline, connections, barges, tenders, personnel, inspection, contracts, plans, and specifications and consist principally of good dredging procedures and the proper use of existing equipment. Recommendations for reducing dredge-induced turbidity include: improved supervision and inspection procedures; improvement of contract specifications; dredging during periods of high background levels of turbidity; and nationwide training for dredging operators, supervisors, and inspectors. This study is the first of a series of reports on possible measures for controlling turbidity. Subsequent work will provide information on flocculants, silt curtains, and submerged pipeline discharge. Proposed additional studies, a selected bibliography of 42 items, and a glossary of 94 terms used in the dredging industry are included in appendices. For a separate section of the report, see the following abstract.

054

Analysis of effects of operational procedures on turbidity generation and control. In: *Techniques for reducing turbidity associated with present dredging procedures and operations*, pp. 17-74. May 1976. Contract Report D-76-4.

The effects of operational procedures on turbidity generation and control in dredging operations are analyzed with respect to dredge plant components, operational techniques, personnel, material classification, and contracts, plans, and specifications. Turbidity generation associated with components of the dredge plant is analyzed, and suggestions on turbidity reduction through maintenance and operation of the components are provided. Better training of dredgemen and inspectors combined with an increase in the number of inspectors are emphasized as being necessary to reduce turbidity resulting from poor technique on the part of dredging personnel. Improvements in the preparation of contracts, plans, and specifications associated with dredging operations and the standardization of a materials classification system will also reduce turbidity. For an overall summary of Contract Report D-76-4, see abstract no. 53.

055

A laboratory study of the turbidity generation potential of sediments to be dredged. Barry A. Wechsler, David R. Cogley. Wilmington, MA, Walden Division of Abcor, Inc., November 1977. Technical Report D-77-14 (NTIS No. AD-A055 646).

In order to elucidate the effects of physical and chemical factors which control particle-settling rates and thereby develop the means to predict the extent of dredging-related turbidity, a series of laboratory jar tests was performed. The turbidity of suspensions of three pure clay samples and eight natural sediments was monitored as a function of time in waters of various salinity, hardness, and pH. A turbidity plume model was developed which accounts for flocculation in suspensions of dredged material. Appendices describe: (1) sediment sampling and handling details; (2) sample characterization procedures; (3) composition of synthetic sea salt, (4) turbidity testing of subscripts-treated sediments; (5) turbidity data; (6) replicate test data; and (7) the plume model computer program. 41 references. (Author abstract modified) For separate sections of this report, see the following two abstracts.

056

Literature evaluation of factors controlling turbidity. In: *A laboratory study of the turbidity generation potential of sediments to be dredged*, pp. 13-25. November 1977 Technical Report D-77-14.

Pertinent literature is reviewed to determine which sediment and water characteristics are likely to affect turbidity. Factors expected to be important based upon previous studies include sediment compositional characteristics, such as particle-size distribution, clay mineralogy, and organic content, water compositional factors including pH, salinity (in estuarine waters), and hardness (in fresh waters), and physical effects influencing coagulation and settling, such as temperature and turbulence. The factors to be investigated experimentally in the study were selected on the basis of this literature review. For an overall summary of Technical Report D-77-14, see abstract no. 61

057

Turbidity plume model. In: *A laboratory study of the turbidity generation potential of sediments to be dredged,* pp. 86-112. November 1977. Technical Report D-77-14.

A turbidity plume model based upon jar-test data was developed as a means of predicting the concentration of suspended sediment downstream from a line source (hydraulic pipeline dredge discharging in open water) as a function of sedimentation data (from jar tests) and hydraulic parameters (eddy diffusion and current velocity, among others). The derivation of the mathematical model, the utilization of jar-test data, the numerical solution method, and a sample calculation are presented. The model predicts the downstream concentration gradient of silt and colloidal-size fractions of dredged sediments discharged in waters characterized by unidirectional constant flow, essentially infinite width, constant depth, and infinite length. Density gradient settling, salt wedges, narrow channels, tidal flows, and complex circulation patterns are beyond the scope of the model in its present state of development. Data in this report were used to develop the final model that is described in Technical Report DS-78-13 (abstract no. 13). For an overall summary of Technical Report D-77-14, see abstract no. 61.

058

Field investigations of the nature, degree, and extent of turbidity generated by open-water pipeline disposal operations. J. R. Schubel, H. H. Carter, R. E. Wilson, W. M. Wise, M. G. Heaton, M. G. Gross. Stony Brook, NY, State University of New York at Stony Brook, Marine Sciences Research Center, July 1978. Technical Report D-78-30 (NTIS No. AD-A058 507).

The characteristics of turbidity plumes in the vicinity of open-water pipeline disposal operations were evaluated, and the distribution and concentration of dissolved heavy metals, nutrients, and dissolved oxygen were assessed. Based on field studies conducted in Corpus Christi Bay (Texas), Atchafalaya Bay (Louisiana), and Apalachicola Bay (Florida), a simple model was developed to predict the spatial and temporal distributions of suspended solids in turbidity plumes. No well-defined plumes of dissolved metals were observed at any of the three sites, indicating that dissolution of metals from the suspended solids was limited. Elutriate test results using the channel sediment were found to have limited use in predicting changes in concentrations of dissolved metals during open-water disposal operations. A simple model was developed to predict concentrations of particle-associated constituents. Although large quantities of reduced sediment with a high oxygen demand are introduced into the water column during open-water pipeline disposal operations, only a small fraction of this material is reactive on a time scale comparable to that associated with the settling of the vast majority of the dredged material slurry. Appendices to this report describe: (1) suspended solids measurements; (2) grain-size analysis of bottom sediments; (3) instrumentation; and (4) chemical analytical methods and model contours. 66 references (Author abstract modified) For separate sections of this report, see the following two abstracts.

059

A suspended solids plume model and its application. In: *Field investigations of the nature, degree, and extent of turbidity generated by open-water pipeline disposal operations,* pp. 102-152. July 1978. Technical Report D-78-30.

The model developed to describe the characteristics of suspended solids plumes which form in shallow estuarine or coastal waters during dredging operations involving open-water pipeline disposal is described. The objective has been to develop a predictive model which would provide maximum information on the spatial distribution of suspended solids concentrations from minimum information on local hydrography, the intensity of advective and dispersive processes, the configuration of the discharge, and the characteristics of the material being discharged. The emphasis has been on simplicity. Results are for a steady and spatially uniform ambient flow field, and they relate to vertically averaged concentrations only. Turbidity plume characteristics are primarily dependent on the discharge rate of the dredge, the settling velocity of the suspended dredged material, the water depth, the hydrodynamic regime (i.e., current velocity and diffusion velocity) of the disposal site, and the age of the plume. Several estimates of dredged material partitioning between the turbidity plume and the bottom layers indicate that 97 to 99 percent of the discharged slurry rapidly settles to the bottom of the disposal area within a few tens of meters of the discharge point. The remaining 1 to 3 percent is incorporated into the plume. For an overall summary of Technical Report D-78-30, see abstract no. 58.

060

Open-water pipeline disposal and dissolved oxygen demand. In: *Field investigations of the nature, degree, and extent of turbidity generated by open-water pipeline disposal operations,* pp. 223-240. July 1978. Technical Report D-78-30.

A simple method for estimating short-term oxygen demand is described and discussed in the context of field observations of oxygen sag in Apalachicola Bay. The estimate of oxygen demand, the demand that was satisfied, is compared with the potential oxygen demand estimated from typical geochemical analyses of interstitial waters of estuarine sediments and with the measured oxygen demands for cores taken in the Apalachicola Bay channel. The oxygen demand estimated from chemical analyses of interstitial waters was about 0.4 mg O_2/g sediment. The oxygen demand measurements from actual cores were about 1.1 mg O_2/g sediment. While the excellent agreement between the oxygen demand calculated from observed oxygen depression and the oxygen demand estimated from interstitial water analyses is somewhat fortuitous, it supports the argument that observed oxygen sags are largely the result of oxidation of easily oxidized dissolved

species in interstitial waters and perhaps, to some extent, of oxidation of the surfaces of sulfide minerals. For an overall summary of Technical Report D-78-30, see abstract no. 58.

061

An analysis of the functional capabilities and performance of silt curtains. Wilmington, MA, JBF Scientific Corp., July 1978. Technical Report D-78-39 (NTIS No. AD-A060 382).

Analytical studies and field measurements were made during actual silt curtain operations to provide guidance on silt curtain usage. When silt curtains, or turbidity barriers, are used to enclose open-water pipeline disposal operations for fine grained material, 95 percent or more of the dredged material slurry descends to the bottom of the disposal area where it forms a fluid mud layer. The remaining 5 percent or less of the dredged material slurry is responsible for the turbidity in the water column. A silt curtain that is properly deployed and maintained provides a mechanism for controlling the dispersion of turbid water by diverting its flow under the curtain. The effectiveness of the silt curtain depends on the nature of the operation, the characteristics of the material in suspension, the type, condition, and deployment of the silt curtain, the configuration of the enclosure, and the hydrodynamic regime present at the site. Under quiescent conditions, turbidity levels outside a curtain that is properly deployed and maintained may be reduced by 80 to 90 percent. An upper limiting current velocity for typical silt curtain usage appears to be approximately 1.5 ft/sec. An alphabetical listing of companies who manufacture silt curtains and whose products were reviewed during this study is appended. 15 references. (Author abstract modified)

062

A field study of fluid mud dredged material: its physical nature and dispersal. [1]Maynard M. Nichols, [1]Galen S. Thompson, [2]Richard W. Faas. [1]Gloucester Point, VA, Virginia Institute of Marine Science; [2]Easton, PA, Lafayette College, July 1978. Technical Report D-78-40 (NTIS No. AD-A058 952).

Open-water disposal of dense suspensions of fluid mud with concentrations of 10 to 480 g/l was studied at field sites in Mobile Bay, Alabama and the James River, Virginia in an attempt to determine the significance of fluid mud in dispersal of dredged material and in generation of turbidity. The bulk of the dredged material, more than 99 percent at the Mobile Bay site, was dispersed in the form of fluid mud near the bottom, whereas less than 1 percent was dispersed through the water column. Disposal created a deposit that spread over an area 5 to 13 times the dredged area in the channel. Disposal raised the bed, forming dense layers in mounds 0.8 to 2.2 m high having slopes 1:125 to 1:2000. Broad spreading at the Mobile Bay site was associated with a high discharge rate over a short period, a low discharge angle, and muds with high plastic and liquid limits. Mounding at the James River site was associated with a moderate discharge rate over a long period, a vertically oriented discharge configuration, and muds with a moderate plastic limit and a relatively low liquid limit. After disposal, the fluid mud consolidated, bulk density increased, and slopes decresed. Height and volume of the James River mound decreased about 50 percent in a year. Appendices to this report describe laboratory procedures. 21 references. (Author abstract modified)

063

Evaluation of the submerged discharge of dredged material slurry during pipeline dredge operations. Robert W. Neal, George Henry, Stephen H. Greene. Wilmington, MA, JBF Scientific Corp., August 1978. Technical Report D-78-44 (NTIS No. AD-A062 616).

A study conducted to investigate the feasibility of using submerged discharge to control the turbidity generated when a pipeline dredge discharges a fine-grained dredged material slurry into open water is described. The program included a survey of field practices, a literature survey, analytical investigations, and numerous flume tests. The experimental investigation was performed at reduced scale in an 8-ft-wide by 32-ft-long by 2.5-ft-deep test tank that was specially constructed for the program. Two series of tests were run. The influence of water type, sediment type, bottom type, solids concentration, and discharge velocity, angle, diameter or area, and height above the bottom was examined. The results of the experimental program demonstrate that striking reductions in turbidity can be realized with a submerged discharge processor that diffuses the flow, minimizes entrainment, and discharges the slurry close to the bottom. The proposed design incorporates a conventional conical diffuser and a radial discharge section. A full-scale submerged discharge diffuser and a support and positioning barge were designed, and a cost estimate was prepared for the detailed design and fabrication of a complete system. Appendices to this report present (1) the results of a survey of Corps of Engineers and private dredge operators who have been involved in open-water discharge and (2) sediment concentration profiles for the baseline and processor tests. 6 references. (Author abstract) For a separate section of this report, see the following abstract.

064

Full-scale predictions. In: *Evaluation of the submerged discharge of dredged material slurry during pipeline dredge operations,* pp. 154-172. August 1978. Technical Report D-78-44.

Methodology for predicting full-scale behavior of dredged material discharges based on tank tests is discussed. Predictions of full-scale mud flow parameters can be made by scaling the experimental results up to a full-scale dredging arrangement. For such predictions to be correct, the full-scale conditions must be geometrically similar to the experimental conditions and must be characterized by the same Froude number. A method for predicting full-scale mud flow parame-

ters is described which involves the use of five sets of curves and six computational steps. The method scales up the parameters of the baseline configuration according to constant Froude numbers and then applies correction factors for those properties that do not match the example. A sample computation shows that a diffuser processor can provide a cloud height of 2 ft off the bottom, while a 20 deg submerged pipe would produce an 11 ft cloud height. For an overall summary of Technical Report D-78-44, see abstract no. 63.

065

Laboratory investigation of the dynamics of mud flows generated by open-water pipeline disposal operations. George Henry, Robert W. Neal, Stephen H. Greene. Wilmington, MA, JBF Scientific Corp., August 1978. Technical Report D-78-46 (NTIS No. AD-A062 480).

The fluid mud system originating at the discharge point of open-water pipeline disposal operations was studied in a laboratory setting. The objective was to define the dynamics of the mud system and to quantify the primary variables that control its behavior, including salt content of the sediment, slurry solids concentration, bottom slope, slurry flow rate, water current, and surface waves. The fluid mud system was characterized by head wave velocity, cloud height, fluid mud layer thickness, concentration profiles, and bottom sediment deposition, with settling playing an important role in the mud system dynamics. When settling was present, the head wave and mud flow slowed down and eventually stopped. In its absence, the mud system sustained its motion. Slurry flow rate and solids concentration influenced the mud system in accordance with the constant densimetric Froude number relationship. Bottom slope indicated the strongest control over the dynamics of the mud system. A minimum downslope angle of 0.75 deg (slope 1:76) was required for the flow to sustain itself. Surface waves set up orbital motion throughout the water column but did not hamper the net forward motion of the mud system. When the bottom orbital velocity exceeded 0.06 fps, suspended sediment at the water column/mudflow interface was transpported upward in the water column. Appendices to this report present: (1) the head wave velocity as a function of downrange distance from the origin; (2) the sediment deposit profiles; and (3) the sediment concentration profiles. 19 references. (Author abstract)

CHAPTER 3: SPATIAL AND TEMPORAL DISTRIBUTION OF DREDGED MATERIAL DISCHARGED INTO HYDROLOGIC REGIMES

066

Sedimentation factors in open water disposal. In: *Disposal of dredge spoil: problem identification and assessment and research program development,* pp. 76-85. November 1972. Technical Report H-72-8.

Sedimentary patterns and processes in estuarine zones, the continental shelves, and the Great Lakes are outlined, particularly in relation to the potential for environmentally compatible disposal of different types of spoil in these areas. The possibilities of deepwater disposal, including ocean basins and submarine canyons are considered. Shoaling reduction and control also are mentioned as possible indirect methods of alleviating spoil disposal problems. For an overall summary of Technical Report H-72-8, see abstract no. 22.

067

Assessment of the factors controlling the long-term fate of dredged material deposited in unconfined subaqueous disposal areas. David R. Basco, Arnold H. Bouma, Wayne A. Dunlap. College Station, TX, Texas A&M University, December 1974. Contract Report D-74-8 (NTIS No. AD-A009 127).

The literature on dispersion of dredged material in waters, particularly estuarine areas, is reviewed as the basis for a subsequent evaluation of factors and mechanisms affecting the ultimate, long-term fate of dredged material. The review covers field studies, model studies, and fundamental studies on sediment transport. A determination is made of the underlying mechanisms involved in scour, transport, and deposition. Field and laboratory methods and equipment for measurement and analysis of all variables of interest are then discussed. Finally, an integrated systems approach to the future study of dredged material dispersion is recommended. A summary of all articles reviewed is appended. 226 references.

068

Investigation of mathematical models for the physical fate prediction of dredged material. Billy H. Johnson. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Hydraulics Laboratory, March 1974. Technical Report D-74-1 (NTIS No. AD-776 368).

Studies relevant to the development of mathematical models of ocean, estuarine, and riverine disposal of dredged material have been identified from the literature and from contact with research groups. The identified studies are summarized in some detail and their limitations outlined. Recommendations are made for additional research needed in this area. The Appendix gives the settling velocities of sediment particles in a water column. 59 references. For separate sections of this report, see the following four abstracts.

069

Transport phenomena in aquatic environments. In: *Investigation of mathematical models for the physical fate prediction of dredged material,* pp. 4-11. March 1974. Technical Report D-74-1.

Following a general discussion of the physical processes responsible for transport phenomena in a turbulent body of fluid, a brief review is made of the results of published studies of diffusion and dispersion coefficients. For an overall summary of Technical Report D-74-1, see abstract no. 68.

070

Models and relevant studies applicable to ocean disposal. In: *Investigation of mathematical models for the physical fate prediction of dredged material,* pp. 12-25. March 1974. Technical Report D-74-1.

Two mathematical models potentially applicable to ocean disposal of dredged material are discussed in detail. These are: (1) the Koh-Chang model for prediction of dispersion and settling in barged ocean disposal of wastes, and (2) the Edge-Dysart model for barge-released dredged material. Other

ocean dispersion studies are briefly reviewed. For an overall summary at Technical Report D-74-1, see abstract no. 68.

071

Transport studies relevant to estuarine disposal. In: *Investigation of mathematical models for the physical fate prediction of dredged material,* pp. 26-33. March 1974. Technical Report D-74-1.

Following a review of published studies in the area of mathematical modeling of tidal hydraulics and estuarine water quality parameters, three mathematical models potentially applicable to estuarine disposal of dredged material are discussed. These are: (1) Van de Kreeke's model for pipeline discharge of dredged material, (2) Lawrence Livermore hybrid Lagrangian-Eulerian three-dimensional particle diffusion code ADPIC, and (3) Stanford Research Institute's modeling effort for disposal in San Francisco Bay. For an overall summary of Technical Report D-74-1, see abstract no. 68.

072

Dispersion studies relevant to riverine disposal. In: *Investigation of mathematical models for the physical fate prediction of dredged material,* pp. 34-43. March 1974. Technical Report D-74-1.

Several mathematical studies of sedimentation in open channel flow are reviewed in relation to their relevance to the development of the dispersion phase of a model of the disposal of dredged material in rivers. The studies reviewed are: (1) formulation of the longitudinal dispersion equation, (2) dispersion of silt particles in open channel flow, (3) entrainment and transportation of sediments in an open channel, (4) a three-dimensional model for diffusion and settling of sediments at river mouths, and a model for river disposal of dredged material. For an overall summary of Technical Report D-74-1, see abstract no. 68.

073

Effects of open-water disposal of dredged material on bottom topography along Texas Gulf Coast. David F. Bastian. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Hydraulics Laboratory, November 1974. Miscellaneous Paper D-74-13 (NTIS No. AD-A002 659).

Hydrographic surveys of hopper dredge disposal areas in the Gulf of Mexico off the coast of Texas were conducted from 1962 to 1973. The disposal areas included Freeport, Port Aransas-Corpus Christi, Brazos Island Harbor, Matagorda Ship Channel, and Port Mansfield. Analysis indicated that dumping at these sites had little effect on bottom topography. 7 references. (Author abstract modified)

074

State-of-the-art survey and evaluation of open-water dredged material placement methodology. Edward E. Johanson, Stuart P. Bowen, George Henry. Burlington, MA, JBF Scientific Corp., April 1976. Contract Report D-76-3 (NTIS No. AD-A027 024).

A study was conducted to establish the feasibility of controlled placement of dredged materials in open water, with special emphasis on the ability to use subaqueous borrow pits as receptors for the dredged material. Extensive investigation of the most comprehensive mathematical model for predicting dredged material behavior once it left the dump vessel was conducted, and an attempt was made to establish improved placement methodology. An innovative way to reduce, or eliminate, dispersion is described. Appendices to the report present (1) the results of the study made to assess the application of the Koh-Chang model to predict the behavior of dredged material after open-water disposal and (2) a discussion of borrow pit navigation systems, including a categorization of electronic positioning systems into three groups depending upon their accuracy. 56 references. For separate sections of this report, see the following three abstracts.

075

Factors affecting open-water placement. In: *State-of-the-art survey and evaluation of open-water dredged material placement methodology,* pp. 3-69. April 1976. Contract Report D-76-3.

The factors relevant to precision open-water placement of dredged material are identified and evaluated, with special emphasis on borrow pits. These factors are presented under the broad categories of: disposal environment (subaqueous borrow pits, dredged material characteristics, and transport mechanisms); operational considerations (navigation and dump phase); and disposal equipment (hopper dredges, barges, and scows). The material discussed in this section is applied to establish the feasibility of open-water placement. For an overall summary of Contract Report D-76-3, see abstract no. 74.

076

Borrow pit dumping: feasibility estimates, and alternatives to extend this feasibility. In: *State-of-the-art survey and evaluation of open-water dredged material placement methodology,* pp. 70-117. April 1976. Contract Report D-76-3.

The feasibility of borrow pit dumping is examined in light of factors identified as being relevant to precision open-water placement of dredged material, and conclusions are drawn as to the feasibility of using existing equipment, essentially without modification. Dredging and transportation to the site, navigation in the borrow pit area, and short-term and long

term behavior of material after the dump are discussed. Several alternative concepts warrant consideration as potential improvements for ocean dumping of dredged material. These include: pump down from hopper dredges; pump down from barges and scows; dredged material modifications; and two approaches to providing better navigational capability (setting up a portable Loran D system, and use of precision systems such as Raydist, LORAC, and some of the Decca systems). For an overall summary of Contract Report D-76-3, see abstract no. 74.

077

Methodology for covering subaqueous borrow pits. In: *State-of-the-art survey and evaluation of open-water dredged material placement methodology,* pp. 118-133. April 1976. Contract Report D-76-3.

Numerous studies of methods and effects of borrow pit covering operations are reviewed. Methods for laying a uniform cover with low-impact energy each require the use of a seagoing hopper dredge. One method distributes the cover material by means of two spray booms that lay down a wide swath on each side of the vessel; this method is limited to noncohesive materials whose settling velocities are approximately 0.5ft/sec. In a second method, the covering material is pumped out of the hoppers and discharged through the submerged dragarm in the proximity of the bottom with zero impact energy. This method places untenable demands on the vessel with regard to navigation, however. Broadcasting systems, such as are used to broadcast seed, are also considered. For an overall summary of Contract Report D-76-3, see abstract no. 74.

078

Development of models for prediction of short-term fate of dredged material discharged in the estuarine environment. Maynard G. Brandsma, David J. Divoky. Pasadena, CA, Tetra Tech, Inc., May 1976. Contract Report D-76-5 (NTIS No. AD-A027 131).

In order to predict short-term fate of dredged material discharged into the estuarine environment, two numerical models were developed--one for instantaneous dumped discharge, and one for moving jet discharge. The models account for land boundaries, depth variations in the estuary, ambient current variations in three dimensions and in time, and variations of ambient density profiles in time. The models are capable of tracking up to 12 classes of solid particles plus the fluid fraction of a discharge through convective descent, dynamic collapse, and passive diffusion phases. A program of model exercise and testing is strongly recommended. When used in cases involving complex ambient velocities, the models will be extremely dependent on good-quality velocity data. Computer realizations of the models and the structure of two computer codes are discussed. A user's manual for both computer programs and a listing of the FORTRAN program for modeling both types of discharge are appended. 29 references. 6-item bibliography. (Author abstract modified) For separate sections of the report, see the following three abstracts.

079

Modeling of dredged material discharged into the estuarine environment. In: *Development of models for prediction of short-term fate of dredged material discharged in the estuarine environment,* pp. 5-24. May 1976. Contract Report D-76-5.

Characteristics of dredged material discharges and estuarine ambient conditions are elements to be considered in modeling of dredged materials discharged into the estuarine environment. The parameters characterizing discharge are those which describe the method of discharge, such as type of vessel, average volume of material discharged, and duration of discharge, and those which describe the physical properties of the discharged material, such as bulk density of material slurry, particle size distribution, particle densities, and void ratios. Modeling for the ambient condition of estuaries must take into account the classification of estuary, type of estuarine circulation, and the approximation of mixing in the estuary. User requirements also have to be considered. For an overall summary of Contract Report D-76-5, see abstract no. 78.

080

Development of mathematical models for dynamic computations. In: *Development of models for prediction of short-term fate of dredged material discharged in the estuarine environment,* pp. 25-76. May 1976. Contract Report D-76-5.

The mathematical treatment of the behavior of dredged material immediately following its discharge from a barge or a pipeline is outlined. Instantaneous dumped discharge and jet discharge of arbitrary duration are analyzed. In either case, the material goes through three phases of motion: convective decent, dynamic collapse, and passive diffusion. The models were developed by coupling the appropriate short-term dynamic portions of the Koh-Chang oceanic disposal model with an extensive modification of a model, originally developed by Fischer, for predicting the fate of chemical wastes in an estuary. The simplest method of discharge is by instantaneous release of material from a hopper barge. Mathematical modeling of the phases of motion is based upon the assumption that the cloud of discharged material will behave as a dense liquid; therefore, buoyant thermal analysis is appropriate. A mathematic formation is presented to account for the convection and collapse of the dredged material jet plume. An extension of the model is provided to cover the situation in which the jet plume encounters the bottom before other hydrostatic forces avert its motion. For an overall summary of Contract Report D-76-5, see abstract no. 78.

081

Development of model for passive diffusion. In: *Development of models for prediction of short-term fate of dredged material discharged in the estuarine environment,* pp. 77-87. May 1976. Contract Report D-76-5.

A mathematical model for passive diffusion of discharged dredged material following instantaneous dumping or jet discharge in the estuarine environment is presented. A scheme developed by Fischer was adapted, and extensive modifications were made to allow for: (1) additional parameters to describe the location of various dredged material constituent clouds; (2) improvements in the treatment of horizontal passive diffusion; (3) addition of vertical diffusion; (4) settling of solid particles; (5) recording of the cumulative distribution of material settled to the bottom; (6) generalization of the diffusion scheme to permit variations in time and space steps; and (7) smooth transition from short-term dynamic computation to long-term passive diffusion. For an overall summary of Contract Report D-76-5, see abstract no. 78.

082

Investigation of subaqueous borrow pits as potential sites for dredged material disposal. Jerald D. Broughton. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Soils and Pavements Laboratory, May 1977. Technical Report D-77-5 (NTIS No. AD-A043 052).

A study was conducted to survey existing knowledge of, inventory, describe, and evaluate the potential for using subaqueous pits, holes, or depressions as dredged material disposal sites. The scope of the study was limited to an investigation of the estuaries, bays, rivers, and continental shelf areas of the Atlantic, Gulf, Pacific, and Great Lakes coasts of the United States. All subaqueous depressions, whether caused by dredging or extraction activities or by natural erosion events, were included. Initial surveys revealed that little research has been accomplished on the effects of pits, holes, or depressions on the aquatic environment. A subaqueous site inventory was made which resulted in the location of approximately 125 former, existing, or potential subaqueous pits, holes, or natural depressions. The data collected for each of these sites were recorded on a specially designed form and were compiled along with site location maps. The data were examined with reference to pertinent literature to obtain qualitative site descriptions. It is concluded that the potential for having or creating man-made subaqueous sites will depend upon demand and supply of the products excavated. 62 references. 58-item bibliography (Author abstract modified)

083

Mathematical model of estuarial sediment transport. Ranjan Ariathurai. Davis, CA, University of California, Davis, Department of Civil Engineering, Robert C. MacArthur, October 1977. Technical Report D-77-12 (NTIS No. AD-A047 207).

A 2-dimensional finite element model for predicting estuarine sediment transport by simulation of erosion, transport, and deposition of suspended sediments is described. The breadth-averaged or depth-averaged equations may be used depending upon the problem to be solved. The governing equations for 2-phase transport are derived and then solved by the finite element method using isoparametric quadrilateral elements in which a quadratic approximation is made for the suspended sediment concentrations. Suspended sediment concentrations and bed profile are provided at each time step. Appendices to the report present: (1) finite element derivations; (2) flow simulation; (3) finite element grid generator; (4) contour plotting using shape functions; and (5) a user's manual for the described model. 31 references. For separate sections of this report, see the following three abstracts.

084

Properties of cohesive sediments. In: *Mathematical model of estuarial sediment transport,* pp. 5-15. October 1977. Technical Report D-77-12.

Descriptions in the literature of the properties of cohesive sediments relevant to the transport process are summarized. These descriptions are essential to an understanding of the model described in this report. Cohesion, aggregation, and settling velocity (effects of concentration, salinity, and depth) are discussed. For an overall summary of Technical Report D-77-12, see abstract no. 83.

085

Transport processes. In: *Mathematical model of estuarial sediment transport,* pp. 16-24. October 1977. Technical Report D-77-12.

Descriptions of estuarial sediment transport processes obtained during a succession of laboratory and field studies are highlighted. Erosion, deposition, and mass balance (which must be obtained either by macroscopic consideration or by integration if the 2-dimensional form of the convection-diffusion equation is to be used) are discussed. The electrochemical bond between cohesive particles first must be broken before detachment and transport of such materials can take place. When the shear stress on the bed is not sufficient to resuspend particles that contact and bond with the bed, deposition occurs. Since the sediment-water system is a binary solid-liquid mixture, the mass balance for sediment must be developed carefully. The various species move at different velocities in a diffusing mixture. In addition, the negatively buoyant sediment particles will settle with respect

to the suspending water, so that the vertical convective velocity of the water differs from that of the sediment by the settling velocity Vs. For an overall summary of Technical Report D-77-12, see abstract no. 83.

086

Simulation of sediment transport in the Savannah Estuary. In: *Mathematical model of estuarial sediment transport,* pp. 48-65. October 1977. Technical Report D-77-12.

Sediment transport was simulated in the Savannah Estuary in Georgia using a 2-dimensional finite element model. Measured and simulated concentration profiles at midstation were compared to determine the accuracy of the simulation. Considering the fact that constant value for settling velocity and diffusion coefficients were used throughout the tidal cycle, the simulated values of suspended sediment concentrations compare very well with the measurements. For an overall summary of Technical Report D-77-12, see abstract no. 83.

087

Field study of the effects of storms on the stability and fate of dredged material in subaqueous disposal areas. Ray B. Krone, Henry J. Bokuniewicz, Jeffrey Gebert, Robert B. Gordon, Peter Kaminsky, Carol C. Pilbeam, Matthew Reed, Catherine Tuttle. New Haven, CT, Yale University, Department of Geology and Geophysics, November 1977. Technical Report D-77-22 (NTIS No. AD-A049 978).

Selected dump sites in Long Island Sound, New York, were investigated following winter storms and a hurricane. Continuous records for at least a year of quantities such as wind velocity, water level, and current speed were utilized to estimate the intensity of infrequent major events. The study concluded that the tidal stream is the dominant source of energy for the resuspension and transport of sediment and that waves do not contribute significantly to dispersion in water depths greater than 60 ft. Recommendations are made concerning the best way to contain silt-clay dredged material. 24 references.

088

Field study of the mechanics of the placement of dredged material at open-water disposal sites. Volume I: Main text and Appendices A–I. Volume II: Appendices J–O. Henry J. Bokuniewicz, Jeffrey Gebert, Robert B. Gordon, Jane L. Higgins, Peter Kaminsky, Carol C. Pilbeam, Matthew Reed, Catherine Tuttle. New Haven, CT, Yale University, Department of Geology and Geophysics, April 1978. Technical Report D-78-7 (NTIS Nos. AD-A055 647, Volume I; AD-A055 648, Volume II).

A field study investigated the mechanics of the placement of dredged material at five open water disposal sites. These included estuarine sites on the Atlantic and Pacific coasts, two sites in the Great Lakes, and one in the open ocean. The objective was to observe all of the processes by which dredged material is emplaced on the bottom at a disposal site. Instrument arrays were designed to define the transit of dredged material in time and space from the moment of its release until its final deposition. Optical transmittance, acoustic pulse echo and water flow measurements with instrument arrays, and water sampling by continuous pumping were among the methods used. The mechanical properties of the dredged material also were studied. Placement proceeds by a three-step process at all localities, involving descent through the water column, impact with the bottom, and spread of a botton surge generated by the impact. The study demonstrates the dependence of the placement processes on water depth, currents at the disposal site, and properties of the dredged material. Appendices to Volume I present data on: (1) dimensions of the hopper dredge *Lyman*; (2) density and distribution of dredged material in the hopper; (3) the potential energy of dredged material; (4) energy flow from the hoppers; (5) energy balance in the descent phase; (6) calculated fall velocity of dredged material; (7) impact properties of dredged material; and (8) field methods. Appendices to Volume II describe the investigations at the Seattle, Ashtabula, New York Bight, Rochester 1976, and Saybrook disposal sites and the mechanics of the placement of dredged material, Rochester field study, 1977. 18 references. (Author abstract modified).

089

Flume experiments on sand, silt and clay mixtures from the offshore dredged material disposal site, Galveston, Texas. Anthony J. Moherek. College Station, TX, Texas A&M University, Department of Oceanography, June 1978. Technical Report D-78-34 (NTIS No. AD-A057 660).

Flume experiments were performed on four sediment mixtures sampled from the offshore Galveston, Texas dredged material disposal site in order to determine their critical erosion velocity, shear stress, and modes of sediment transport. An analysis of the offshore Galveston hydrographic regime also was performed using meteorologic and oceanographic data. The results of the flume experiments indicate that that the four sediment mixtures eroded similarly. Extrapolation of flume results to recorded offshore bottom current speed measurements indicates that bedload erosion occurs much more frequently near the northern margin of the disposal site. Also, net bedload transport of disposal material is oriented down the coast or offshore from the disposal site, suggesting that material will not likely return to the channel proper as shoaling sediment. Appendices to this report present: (1) total suspended matter concentration, time after velocity change, mean flow speed, and water sample locations obtained during experimental runs, (2) current velocity profiles and shear stress calculations for experimental runs, (3) graphs of experimental runs, (4) washload grain-size analyses, and (5) Reynolds and Froude number calculations. 42 references. (Author abstract)

090

Evaluation and calibration of the Tetra Tech dredged material disposal models based on field data. [1]Billy H. Johnson, [2]Barry W. Holliday. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, [1]Hydraulics Laboratory; [2]Environmental Laboratory, August 1978. Technical Report D-78-47 (NTIS No. AD-A060 250).

The results of an evaluation and calibration of two Tetra Tech, Inc. mathematical dredged material disposal models are presented based on field data. The models were developed for the purpose of predicting the short-term physical fate of material disposed in an estuarine environment by an instantaneous disposal operation or a continuous discharge disposal. The Hydraulics Laboratory of the U.S. Army Engineer Waterways Experiment Station has been involved in an evaluation and calibration of these models since the latter part of 1976. Model evaluation has centered around an analysis of the conceptualization of the physical processes and the corresponding theoretical description of those processes. In this phase, computer programming errors have been corrected and several modifications have been made to the models in order to represent the disposal processes more realistically. Model calibration has centered around determining the most realistic way to apply the models to a particular disposal operation and a subsequent variation of model coefficients to match computed results with data collected during Dredged Material Research Program (DMRP) sponsored field studies by Yale University (DMRP Work Unit 1B09 reported by Bokuniewicz et al. in Technical Report D-78-7 (abstract no. 88)). The findings indicate that the models can realistically simulate what happens in the water column during the release; however, they cannot accurately describe the detailed structure of the impact and subsequent bottom surge as observed and discussed in Bokuniewicz et al. Appendices to this report present: (1) the input list for the instantaneous dump model; (2) the input list for the continuous discharge model; (3) a listing of the program to generate the velocity tape at the Duwamish, Washington, disposal site; and (4) an example problem combining results from both dredged material models. 5 references. (Author abstract)

CHAPTER 4: POLLUTIONAL PROPERTIES OF DREDGED MATERIAL AND ASSESSMENT TECHNIQUES

091

Spoil composition and characteristics. In: *Disposal of dredge spoil: problem identification and assessment and research program development,* pp. 21-34. November 1972. Technical Report H-72-8.

Following a review of the physical, engineering and chemical properties of dredge spoil, problems in sampling bottom sediments and dredge spoils are discussed, particularly in relation to the Environmental Protection Agency criteria for determining acceptability of dredged spoil disposal to the nation's waters. For an overall summary of Technical Report H-72-8, see abstract no. 22.

092

Literature review on research study for the development of dredged material disposal criteria. G. Fred Lee, Russell H. Plumb, Jr. Dallas, TX, University of Texas at Dallas, Institute for Environmental Studies, June 1974. Contract Report D-74-1 (NTIS No. AD-780 755).

An extensive literature review was done as part of an effort to establish relationships between the presence of various contaminants within sediments and the effects of sediment dredging and disposal on water quality and aquatic organisms. The review revealed little or no evidence of any relationship between bulk-sediment composition and pollutional tendencies of dredged sediment. Use of criteria for dredged material disposal that are based on parameters employed in evaluating environmental impact of domestic and industrial wastewaters is considered to be unrealistic. An Elutriate Test, developed by the Environmental Protection Agency and the Corps of Engineers, is superior to bulk analysis, since it recognizes that all chemicals in sediment are not equally available to aquatic organisms. This initial effort was followed by additional research into sediment/water quality relationships (see Contract Reports D-74-1 and D-75-4). 163 references. (Author abstract modified) For separate sections of this report, see the following three abstracts.

093

Dredged material disposal criteria. In: *Literature review on research study for the development of dredged material disposal criteria,* pp. 4-9. June 1974. Contract Report D-74-1.

Reasons are given why water quality criteria such as chemical oxygen demand, total Kjeldahl nitrogen, volatile solids, and oil and grease are not applicable to bulk dredged material. A more suitable criterion, the Elutriate Test, is discussed in detail in the following abstract. For an overall summary of Contract Report D-74-1, see abstract no. 92.

094

[Dredged material disposal criteria: the Elutriate Test.] In: *Literature review on research study for the development of dredged material disposal criteria,* pp. 10-54. June 1974. Contract Report D-74-1.

This test involves the mixing of one volume of the sediment which is to be dredged with four volumes of the disposal site water for a 30-minute shaking period. A 1-hour settling period followed by filtration or centrifugation is used to determine the release of potentially significant chemical constituents from the sediment. A 1.5 factor has been established as a critical value for the release of contaminants from the sediment to be dredged. The basis for this factor and precautions to be observed in its application are discussed. Factors affecting the results of the Elutriate Test include: solid-liquid ratio, time of contact, pH, dissolved oxygen concentration, agitation, particle size, handling of solids, characteristics of water and sediment, and solid-liquid separation. For an overall summary of Contract Report D-74-1, see abstract no. 92.

095

Previous dredged material studies. In: *Literature review on research study for the development of dredged material disposal criteria,* pp. 55-126. June 1974. Contract report D-74-1.

The literature on (1) biological, biochemical, and turbidity problems, (2) bulk properties of dredged material and

sediment, (3) interstitial water composition, and (4) release of oxygen, nutrients, heavy metals and organic compounds from sediment is reviewed. For an overall summary of Contract Report D-74-1, see abstract no. 92.

096

Discussion of regulatory criteria for ocean disposal of dredged materials: Elutriate Test rationale and implementation guidelines. John W. Keeley, Robert M. Engler. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Office of Dredged Material Research, March 1974. Miscellaneous Paper D-74-14 (NTIS No. AD-755 826).

Guidelines are provided for implementing the Standard Elutriate Test, the basic analytic procedure for determining the pollutional status of material to be disposed. The test is designed to measure the amount of any chemical constituent dissolved in sediment interstitial water and also those constituents which, due to dredging, migrate from the solid phase to the dissolved phase. The rationale for dredge site sampling is discussed. 15 references.

097

Research study for the development of dredged material disposal criteria. Final report. G. Fred Lee, Marvin D. Piwoni, Jose M. Lopez, George M. Mariani, Jeannie S. Richardson, David H. Homer, Farida Saleh. Richardson, TX, University of Texas at Dallas, Institute for Environmental Sciences, November 1975. Contract Report D-75-4 (NTIS No. AD-A019 953).

A literature review and preliminary laboratory studies of the factors influencing the release of chemical contaminants from natural water sediment are presented, with emphasis placed on the factors affecting the results of the Elutriate Test for evaluation of the potential environmental impact of dredging and dredged material disposal. The Elutriate Test was employed to evaluate the release of contaminants from hydraulically dredged sediments from the Trinity River, Houston Ship Channel turning basin, Port Aransas Channel, and Corpus Christi Bay, Texas; Mobile Bay, Alabama; Bridgeport, Connecticut; and Ashtabula, Ohio, Harbor on Lake Erie. Various aspects of exchange between water and sediment are reviewed, and the results of the evaluation of the Elutriate Test for nitrogen and phosphorus, heavy metals, and chlorinated hydrocarbon pesticides and polychorobiphenyls are discussed. The results of the Elutriate Test are applied to the development of dredged material disposal criteria. The Appendix to the report contains information on modified Elutriate Test procedures. 189 references. For separate sections of this report, see the following three abstracts.

098

Factors influencing Elutriate Test performance. In: *Research study for the development of dredged material disposal criteria*, pp. xxiv-xxxii. November 1975. Contract Report D-75-4.

The standard Elutriate Test and modifications were utilized to evaluate the release of nitrogen, phosphorus, iron, manganese, copper, lead, zinc, cadmium, and selected chlorinated hydrocarbon pesticides and polychlorobiphenyls in collected sediment and water samples. Elutriate Test operating parameters investigated include: method of filtering, sample size, method and time of agitation, oxygen concentration, amount of sediments in the elutriate mixture, type of water, and settling time. The literature on the environmental chemistry of nitrogen and phosphorus compounds, heavy metals, and chlorinated hydrocarbon pesticides and other organic contaminants in natural water sediments is reviewed. For an overall summary of Contract Report D-75-4, see abstract no. 97.

099

Sediment oxygen demand during the Elutriate Test. In: *Research study for the development of dredged material disposal criteria*, pp. 235-302. November 1975. Contract Report D-75-4.

The results of preliminary studies of the oxygen demand of sediments and the oxygen status of the test solution during the Elutriate Test are presented. Initially, no attempt was made to control the extent of oxygenation of the test solution during the course of this test, and variable responses for the release of nutrients and heavy metals under supposedly identical test conditions resulted. The subsequent use of air bubbling for sample mixing improved the reproducibility of results for identical tests and provided a well-defined redox condition. Finally, changes in dissolved oxygen occurring during the Elutriate Test were investigated in order to permit better comparison of test results with actual field situations involving dredging and dredged material disposal. For an overall summary of Contract Report D-75-4, see abstract no. 97.

100

Application of Elutriate Test results to development of dredged material disposal criteria. In: *Research study for the development of dredged material disposal criteria*, pp. 303-310. November 1975. Contract Report D-75-4.

A modified Elutriate Test is proposed which employs compressed air mixing of the elutriate and incorporates a change in the sediment percentage of the total elutriate volume from that originally proposed by the U.S. Environmental Protection Agency and Army Corps of Engineers (20 percent) to 5 percent. This approach would greatly improve the yield of elutriate for chemical analysis and would increase the ease of performance of the test without any harm to test result

interpretation. Studies to ensure accurate Elutriate Test result interpretation are recommended. For an overall summary of Contract Report D-75-4, see abstract no. 97.

101

Selective analytical partitioning of sediments to evaluate potential mobility of chemical constituents during dredging and disposal operations. James M. Brannon, Robert M. Engler, Janet R. Rose, Patrick G. Hunt, Isaac Smith. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Effects Laboratory, December 1976. Technical Report D-76-7 (NTIS No. AD-A035 247).

The results of a study conducted to determine the partitioning of various elements in dredged material and their effect on water quality are presented. In order to assess the impact of dredged material discharge upon water quality, especially as reflected by the Elutriate Test, and to elucidate the form and species of contaminants in sediments, a functionally derived sediment selective extraction procedure was developed. This procedure explores the association of trace metals and other elements or compounds within sediments and their distribution among sediment phases of varying stability and mobility. The procedure was used on marine, estuarine, and freshwater sediments representing a wide range of contaminant concentrations, organic and inorganic carbon contents, and physical characteristics. The partitioning of chemical constitutents in these sediments has shown the concentrations of trace metals and nutrients in the standard elutriate to be correlated statistically in most cases with their respective concentrations in the interstitial water, exchangeable, and easily reducible phases. The toxic heavy metal or nutrient concentrations in the standard elutriate therefore represent that sediment phase thought to be most mobile and biologically available to the aquatic environment. Appendices to this report give: (1) sediment and water column characteristics; (2) chemical concentrations and percent extracted in the various chemically extracted sediment phases; and (3) f-values from analyses of variance of data. 90 references.

102

Bioassessment of the standard elutriate test. Peter J. Shuba, Joe H. Carroll, Henry E. Tatem. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Effects Laboratory, September 1976. Miscellaneous Paper D-76-7 (NTIS No. AD-A030 793).

Biological assessment studies of the standard elutriate were conducted using selected species of algae, bacteria, and protozoans as representative test organisms and sediments from Ashtabula Harbor (Ohio) and the Houston (Texas) Ship Channel. Growth was determined by measuring the maximum number of cells per milliliter of treatment. The treatments included 100 percent disposal site water, 100 percent elutriate, and various combinations of the two sample types. Elutriates prepared from some locations stimulated algal growth when compared with the growth obtained in the disposal site water. Other elutriate preparations demonstrated an inhibitory effect toward growth of the test algae. The algal assay procedure is considered a useful method for evaluating the potential effects of dredging and dredged material disposal on phytoplankton at the proposed discharge site. 16 references. (Author abstract modified)

103

Ecological evaluation of proposed discharge of dredged or fill material into navigable waters. Interim guidance for implementation of Section 404(b)(1) of Public Law 92-500 (Federal Water Pollution Control Act Amendments of 1972). Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Effects Laboratory, May 1976. Miscellaneous Paper D-76-17 (NTIS No. AD-A026 882).

Interim guidance prepared pursuant to Section 230.4-1 of the *Federal Register* (Vol. 40, No. 173) is provided for use in the ecological evaluation of the proposed discharge of dredged or fill material in navigable waters according to Section 404(b) of Public Law 92-500. The basic philosophy underlying ecological evaluation is summarized, and the general procedures to be employed are outlined. General approaches for technical evaluation are discussed under three headings: physical effects, chemical/biological interactive effects, and procedures for site comparison. Appendices contain stepwise procedures for: (1) conducting an elutriate test; (2) estimating a mixing zone; (3) performing bioassays; (4) conducting total sediment analyses; and (5) evaluating biological community structure. These procedures contain all references and citations pertinent to the various evaluative procedures. This report attempts to provide a balance between the technical state-of-the-art and routinely implementable guidance for using the procedures specified in the *Register* and is expected to provide a continuity among the Corps Districts' evaluation programs for Section 404 permit activities. 14 references. (Author abstract modified)

104

Distribution of manganese, nickel, zinc, cadmium, and arsenic in sediments and in the standard elutriate. James M. Brannon, Robert M. Engler, Janet R. Rose, Patrick G. Hunt, Isaac Smith. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Effects Laboratory, June 1976. Miscellaneous Paper D-76-18 (NTIS No. AD-A026 355).

As part of a program to determine the environmental soundness of open water disposal of dredged material, sequential, selective chemical extraction (partitioning) was used to separate estuarine (Mobile Bay, Alabama), freshwater (Ashtabula, Ohio), and marine (Bridgeport, Connecticut) sediments into the fractions: (1) dissolved in sediment interstitial water, (2) adsorbed on mineral surfaces, (3) associated with hydrous iron and manganese oxides and hydroxides, (4) associated with sediment organic matter and sulfides, and (5) bound within the lattice of crystalline minerals and the interlayer positions of phyllosilicate (clay) materials.

Separate sediment extractions using the Elutriate Test also were performed. Manganese, nickel, cadmium, zinc, and arsenic concentrations were determined in each extractant. No relationship existed between trace metal concentration in the standard elutriate and total metal concentration in the sediment. Trace metal concentrations in the sediment phases thought to be the most mobile were related to their respective concentrations in the standard elutriate. 45 references. (Author abstract modified)

105

Biological assessment of the soluble fraction of the standard elutriate test. Peter J. Shuba, Joe H. Carroll, Karon L. Wong. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Effects Laboratory, March 1977. Technical Report D-77-3 (NTIS No. AD-A040 087).

Results obtained from the bioevaluation of the standard elutriate test using a variety of marine and freshwater algae, bacteria, and protozoans are presented. The organisms were selected because of their specific importance in aquatic ecosystems and their overall importance in the cycling of nutrients and heavy metals. Sediment samples were selected from Bridgeport Harbor, Ashtabula River, Galveston Harbor, and Arlington Channel of Mobile Bay, and water samples were obtained from their corresponding disposal sites. The report evaluates the results in relation to water quality criteria and predicted field impacts. It is recommended that the algal bioassay be used in evaluating the biological effects of the chemical constituents released from sediment and their potential effect on phytoplankton at dredged material disposal sites. (More recent bioassay research has shown the algal assay not to be as effective a predictor of potential for harm as the animal assays.) Moreover, additional water-column bioassays using selected zooplankton species should be initiated and developed and benthic bioassay development should be initiated immediately to determine the effects of dredged material disposal on benthic species as well as possible long-term effects of these operations. Appendices to this report (1) describe microbial growth media and (2) give algal growth curves. 32 references. For a separate section of the report, see the following abstract.

106

Algal, protozoan, and bacterial assays. In: *Biological assessment of the soluble fraction of the standard elutriate test*, pp. 22-32. March 1977. Technical Report D-77-3.

Bioassays were conducted to determine the effect of soluble chemicals released during disposal of dredged material on microbial communities. The algal assays used various test organisms in four dredging sites. Both stimulatory (Bridgewater and Galveston samples) and inhibitory effects (Arlington Channel samples) were reported when growth in the elutriate was compared to growth in disposal site water. All sediments used to prepare standard elutriates were tested to demonstrate the release of ammonium-nitrogen. Growth studies were conducted using the marine alga *Dunaliella tertiolecta* exposed to the concentrates of ammonia found in the elutriates. The concentrations used were not toxic to the test organisms. The bacterial and protozoal bioassays produced nonsignificant results, because growth media had to be added in most cases to obtain a measurable response. For an overall summary of Technical Report D-77-3, see abstract no. 105.

107

Evaluation of the elutriate test as a method of predicting contaminant release during open-water disposal of dredged sediments and environmental impact of open-water dredged material disposal. Volume I: Discussion. R. Anne Jones, G. Fred Lee. Richardson, TX, University of Texas at Dallas, Environmental Chemistry, August 1978. Technical Report D-78-45 (NTIS No. AD-A064 014).

The main text of a study conducted to evaluate the factors influencing the results of the elutriate test and the reliability of this test in predicting the release of contaminants during actual open-water dredged material disposal operations is presented. Sediment samples were taken from 26 waterway locations representing marine, estuarine, and freshwater locations. Field investigations were conducted at eight active dredging and disposal operations in marine, estuarine, and freshwater areas so that a comparison could be made between the results of the standard and modified elutriate tests for water column concentrations during disposal operations. Individual sections of the report cover the following subjects: (1) overall characteristics of dredged material disposal operations in relation to elutriate test development, (2) evaluation of the applicability of the elutriate test, (3) factors influencing the results of this test, (4) environmental impact of turbidity and suspended solids associated with dredged material disposal operations, (5) bioassays, (6) bioaccumulation of persistent contaminants, and (7) the current legislation, including some of the foundation legislation, pertaining to regulation of dredged sediment disposal in open waters. Summary tables of (a) phosphate release from dredged sediment, (b) elutriate test results for heavy metals, (c) nitrogen compound concentrations in the elutriates and site water for all sites studied, (d) elutriate test results for organic analyses, and (e) acute toxicity for selected U.S. waterway sediments are appended. 90 references.

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Evaluation of the elutriate test as a method of predicting contaminant release during open-water disposal of dredged sediments and environmental impact of open-water dredged material disposal. Volume II: Data report. G. Fred Lee, Rebecca A. Jones, Farida Y. Saleh, George M. Mariani, David H. Homer, Jeannie S. Butler, Pinaki Bandyopadhyay. Richardson, TX, University of Texas at Dallas, Environmental Chemistry, August 1978. Technical Report D-78-45 (NTIS No. AD-A061 710).

The laboratory and general field procedures used to evaluate the factors influencing the results of the elutriate test and the reliability of this test in predicting the release of contaminants during actual dredged material disposal operations are described. Sediment samples taken from 26 waterway locations were subjected to the standard and modified elutriate test in order to examine the influence of various factors on test results. In addition, field studies were conducted which compared the results of the standard and modified elutriate tests and water column concentrations during disposal operations. The findings indicate that the standard elutriate test, involving 30-minute mixing and one-hour settling, is a reliable test for predicting the potential release of contaminants associated with hydraulically dredged sediments that are dumped in open water. They also show that the open-water discharge of dredged sediments, including those which are highly contaminated with various types of chemical toxicants, would rarely cause an adverse effect on water quality and aquatic organisms in the disposal site water column. The Appendix consists of 41 data tables, 39 references. (Author abstract modified)

109

Long-term release of contaminants from dredged material. James M. Brannon, Russell H. Plumb, Jr., Isaac Smith. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, August 1978. Technical Report D-78-49 (NTIS No. AD A060 814).

The results of an 8-month aerobic leaching study conducted to investigate the magnitude and predictability of long term release of chemical constituents from dredged material are presented. The report discusses the use of sediment/water column simulations in the laboratory with a large number of sediments (32) representing a broad geographical and pollutional variation and selected from marine, estuarine, and freshwater areas to assess their long term release of contaminants. The sediment/water systems were studied under aerobic quiescent and mixed conditions. Various sediment chemical analyses, including the elutriate test and bulk sediment analysis, were conducted to identify and evaluate relationships between sediment chemical characteristics and the long-term leaching of chemical constituents. Results of the long-term leaching investigation demonstrate that under the aerobic chemical conditions likely to prevail at aquatic disposal sites, total organic carbon, orthophosphate-P, and zinc exhibited the most consistent net releases to the water column. Worst-case evaluation of the potential effects of contaminant releases indicates that sediments used in this study would not be expected to cause significant long term water quality problems. The elutriate test (modified for aeration) and interstitial water analyses demonstrated considerable utility as predictors of potential long-term net mass release of contaminants from sediments. Tables of chemical constituent concentrations are appended. 75 references. (Author abstract modified)

110

Biological assessment methods to predict the impact of open-water disposal of dredged material. Peter J. Shuba, Henry E. Tatem, Joe H. Carroll. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, August 1978. Technical Report D-78-50 (NTIS No. AD-A060 502).

Numerous bioassay experiments are described in which representative aquatic invertebrates were exposed to heavily contaminated sediments and standard liquid (elutriate) and suspended particulate phases of the sediments in an attempt to develop biological methods for assessing the effects of open-water disposal of dredged material on water column and benthic animals, prior to actual disposal. Test sediments were obtained from areas where chemical contaminants were known to be present, such as the Duwamish River at Seattle and New York Harbor shipping channels. Chemical analyses of these materials revealed the presence of metals, chlorinated hydrocarbons, petroleum hydrocarbons, and other contaminants. Animals used in the experiments included marine, estuarine, and freshwater forms such as shrimp, clams, small crustaceans, polychaete worms, and others. The results of numerous acute bioassays with contaminated sediments indicate that sediment elutriates and suspended particulate phases may be toxic to small crustaceans under some circumstances. It was found also that exposure of sensitive benthic animals to these sediments resulted in significant toxicity in some cases. However, the above findings were generally the exception and not the rule and are subject to many qualifications. It is recommended that additional work be conducted to determine the normal variability in bioassays conducted with sediments and to establish standard laboratory species for tests of this type. Appendices describe (1) the composition of reconstituted fresh water, (2) the ionic composition of instant ocean synthetic sea salt, (3) the method of analysis for polychlorinated biphenyls (PCBs), and (4) the methods of analysis for kepone and heavy metals. 37 references. (Author abstract modified)

111

An evaluation of oil and grease contamination associated with dredged material containment areas. Austin, TX, Engineering-Science, Inc., November 1977. Technical Report D-77-25 (NTIS No. AD-A048 595).

The potential problem of contamination of receiving waters by oil and grease in return waters from dredged material confined disposal areas is addressed. As a part of this study, field studies were conducted at six locations where dredging is practiced, and both water and sediment samples were collected. Sample analysis indicated generally that oil and grease are not released from sediments in significant amounts as a result of dredging. The report also contains an evaluation of oil and grease sampling and analytical techniques and a literature review of potential treatment methods for the reduction of the oil and grease contents of disposal area

return waters. The Appendix contains sampling and laboratory procedures. 43 references.

112

Characterization of confined disposal area influent and effluent particulate and petroleum fractions. James C. S. Lu, Bert Eichenberger, Miroslav Knezevic, Kenneth Y. Chen. Los Angeles, CA, University of Southern California, Environmental Engineering Program, May 1978. Technical Report D-78-16 (NTIS No. AD-A056 371).

A detailed analysis of contaminants in influents and effluents from confined dredged material disposal areas located at Pinto Island, Mobile Bay, Alabama, and Grassy Island, Detroit, Michigan, is presented. The results from this study show that most trace metals, oil and grease, chlorinated pesticides, and polychlorinated biphenyls (PCB's) were associated almost totally with settleable (greater than 8 mu) solids in influent, effluent, and background water samples; their removal efficiencies usually were very close to the total solids removal. However, significant quantities of the major ions (calcium, magnesium, sodium, and potassium), ammonium nitrogen, total carbon, and organic carbon were associated with the soluble phase (less than 0.05 mu fraction). Removal efficiency of parameters mainly associated with the soluble phase was much lower than for the parameters mostly bound with settleable solids. The findings of this report, in conjunction with the findings of other related studies, strongly indicate that land disposal of dredged material should not impact the environment if settleable solids are removed before effluent discharge. However, during this field study, low dissolved oxygen levels, as well as solid-phase concentrations of oil and grease, some chlorinated hydrocarbons, and total phosphorus, were observed occasionally in effluents (especially at Pinto Island, where effluent suspended solids were highest). Appendices to the report contain: (1) a vegetative listing for Pinto Island; (2) analytical methods used; and (3) analytical laboratory data. 19 references. (Author abstract modified)

113

A study of leachate from dredged material in upland areas and/or in productive uses. Final report. James L. Mang, James C. S. Lu, Ronald J. Lofy, Robert P. Stearns. Long Beach, CA, SCS Engineers, June 1978. Technical Report D-78-20 (NTIS No. AD-A056 897).

A laboratory lysimeter study investigated the composition of subsurface leachates generated from five different dredged materials, each combined with one of two subsurface soil profiles. The dredged materials were from land disposal areas located near Mobile, Alabama (saline silty clay); Sayreville, New Jersey (saline silty loam); Grand Haven, Michigan (freshwater sandy clay loam); Seattle, Washington (saline silty loam); and Houston, Texas (saline silty clay). The native soils included a low organic, moderately permeable semiarid soil obtained from arable land near Hemet, California and a highly organic upland sandy loam soil obtained from a temperate coniferous forest near Lake Arrowhead, California. The results from this study indicate that leachate quality may be governed both by the dredged material and the underlying soil. The discussion emphasizes the migration of constituents in dredged material/interfacing soil systems, the mechanisms which control it, and the impact of dredged material leachates on water quality. Analytical procedures used in the study are appended. 454 references. 454-item bibliography.

114

Physical and chemical characterization of dredged material influents and effluents in confined land disposal areas. Ronald E. Hoeppel, Tommy E. Myers, Robert M. Engler. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, June 1978. Technical Report D-78-24 (NTIS No. AD-A057 460).

Nine dredged material confined land disposal areas, located at upland, lowland, and island sites, were monitored during hydraulic dredging operations in fresh-water and brackish-water riverine, lake, and estuarine environments. The parameters measured included nutrients, heavy metals, oil and grease, chlorinated pesticides, polychlorinated biphenyls (PCB's) and various field and laboratory physico-chemical measurements. A literature review precedes the presentation of the study. Study results show that most heavy metals, oil and grease, chlorinated pesticides, and PCB's are associated almost totally with settleable solids in influent, effluent, and surface background water samples. Only net nitrate-nitrite nitrogen, zinc, calcium, copper, and potassium concentrations were found to increase in the soluble phase of dredged material during land confinement, but the increases were either small or levels were higher in the collected background water. These findings strongly indicate that the land confinement of dredged material should not impact the environment if the site is managed to limit residence to the maximum time for effective solids removal. If settling of fine suspended solids cannot be attained with residency of one or two days, other measures should be considered, including multiple pond treatment or flocculant use. Appendices to this report contain (1) dredging logs and (2) field and analytical laboratory data. 159 references. (Author abstract modified)

115

Physical and chemical characterization of dredged material sediments and leachates in confined land disposal areas. [1]Kar Y. Yu, [1]Kenneth Y. Chen, [2]Robert D. Morrison, [2]James L. Mang. [1]Los Angeles, CA, University of Southern California, Environmental Engineering program, [2]Long Beach, CA, SCS Engineers, August 1978. Technical Report D-78-43 (NTIS No. AD-A061 846).

The water quality effect of the disposal of dredged material in confined upland areas in Grand Haven (Michigan), Sayreville (New Jersey), Houston (Texas), and Pinto Island (Alabama) was determined. Each case study site was selected on the basis of distinct physical settings. Twenty-six sampling de-

vices were installed at each site--12 on-site, 10 off-site, and 4 beneath the site. Water samples were collected four times in nine months; soil and dredged material samples were collected during the first sampling visit. Analytical data show some significant increase in concentrations of chloride, potassium, sodium, calcium, magnesium, total organic carbon, alkalinity, iron, and manganese in downgradient groundwaters. Concentrations of chlorinated hydrocarbons, cadmium, copper, mercury, lead, zinc, phosphate, and nickel were generally very low. Results obtained from this limited monitoring period have shown some degradation of groundwater quality due to the upland disposal of dredged material. Additional data are needed to formulate guidelines for the selection of disposal sites with minimal environmental impacts. Appendices to this report contain: (1) climatological data for the Grand Haven case study site; (2) well logs for the Grand Haven site; (3) climatological data for the Sayreville case study site; (4) well logs for the Sayreville site; (5) climatological data for the Houston case study site; (6) well logs for the Houston site; (7) climatological data for the Pinto Island case study site; (8) well logs for the Pinto Island site; (9) soil and dredged material physical and chemical characteristics; (10) soil and dredged material pesticide and metals analysis; (11) leachate/interstitial water analyses; and (12) analytical procedures. 225 references. (Author abstract)

CHAPTER 5: PHYSICAL, CHEMICAL, AND BIOLOGICAL TREATMENT OF CONTAMINATED DREDGED MATERIAL

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[Dredging and disposal techniques and equipment: treatment processes.] In: *Disposal of dredge spoil: problem identification and assessment and research program development*, pp. 85-99. November 1972. Technical Report H-72-8.

Present status of the dredging industry, its personnel, equipment, and operations are discussed. Feasible improvements in equipment include new designs of cutterheads, cutterhead shields, flow measuring devices, and dredges such as the 'Mud Cat' which are optimized for operation with a minimum of turbidity. The use of chemical additives, modified cutterhead operation, and precision dredging are some of the available new operational techniques. New or modified disposal practices include: silt curtain barriers, bubble barriers, long-distance pipeline transport, road and rail transport, makeup water requirements, spillage control, and placement control. Polluted spoil material can be treated, either before or during dredging, by aeration or chemical methods. Treatment methods used for disposal of polluted spoil materials potentially include: flocculation, hydrocyclones, aeration, incineration, filtration and, in some cases, treatment by sewage disposal plants. For an overall summary of Technical Report H-72-8, see abstract no. 22.

117

Treatability of dredged material. (Laboratory study). Thomas K. Moore, Brooks W. Newbry. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Effects Laboratory, February 1976. Technical Report D-76-2 (NTIS No. AD-A022 143).

The potential for treatment of dredged material as it is being disposed in open water and of effluent from material that has been deposited in confined (diked) areas was investigated. Dredged sediment material and liquid samples were collected at three sites in Mobile Bay, Alabama, at one site in Maumee Bay, Ohio, and at one site in Mare Island Strait, California. Standard analytical tests were performed to determine the chemical and physical characteristics of the dredged materials. From the analyses conducted, an assessment was made of the adequacy of 18 physical and chemical parameters as indices of environmental quality. The test results support the observation that many conventional wastewater treatment techniques are inapplicable and/or impractical for treatment of dredged material. Three alternative systems are recommended. 28 references. For a separate section of this report, see the following abstract.

118

Dredged material treatment systems. In: *Treatability of dredged material. (Laboratory study)*, pp. 86-96. February 1976. Technical Report D-76-2.

Alternative systems offering potential for treatment of dredged material are examined. (1) In-line aeration provides a means of satisying the immediate oxygen demand and, thus, of reducing or eliminating the adverse effects of depletion of dissolved oxygen in the receiving water body. (2) Treatment by confinement of dredged material in diked areas takes advantage of natural sedimentation processes to separate solid and liquid fractions. (3) A system of vacuum filtration, though experimental, offers the advantages of a more rapid means of fraction separation and a smaller confined disposal area requirement than the confined area needed when only natural sedimentation treatments are involved. (4) Other dewatering techniques also are discussed. The results of this study were used as one basis to determine what techniques warranted further study. In-line aeration/oxygenation was further evaluated (Technical Report D-77-15) and was found to be of marginal value. The cost of vacuum filtration limits the feasibility of this technique (see Technical Report D-78-5). Final treatment guidelines are presented in Technical Report DS-78-14. For an overall summary of Technical Report D-76-2, see abstract no. 117.

119

Oxygenation of dredged material by direct injection of oxygen and air during open-water pipeline disposal. Robert W. Neal, R. B. Pojasek, J. C. Johnson. Wilmington, MA, JBF Scientific Corp., October 1977. Technical Report D-77-15 (NTIS No. AD-A046 487).

A study conducted to investigate the feasibility and effectiveness of injecting an oxidant into the discharge of a hydraulic

dredge in order to reduce the depletion of dissolved oxygen in an open-water disposal area is described. Two full-scale field demonstrations, one injecting pure oxygen and the other injecting compressed air into the discharge line, were carried out. The chemical processes responsible for the oxygen depletion in the receiving water during dredging and dredged material disposal operations are discussed. An analytical method for measuring and studying the immediate oxygen demand is also presented. The configuration and cost of injection systems for full-scale dredging operations are examined. Appendices give: (1) analytical methods used; (2) sample calculations; (3) a description of dredging projects; and (4) a cost estimate of a 13.7-ton/day oxygen plant. Because of apparent limited effectiveness (i.e., little increase in dissolved oxygen in the water column and a short-term increase in the fluid mud), readers should consult the discussion in Technical Report DS-78-14 which presents qualified recommendations. 76 references. (Author abstract modified) For a separate section of this report, see the following abstract.

120

[Comparison of oxygen and hydrogen peroxide systems.] In: *Oxygenation of dredged material by direct injection of oxygen and air during open-water pipeline disposal,* pp. 183-189. October 1977. Technical Report D-77-15.

The respective concepts, design bases, and costs of oxygen and hydrogen peroxide injection systems for full-scale dredging operations are compared. For a variety of locations, it appears that the cost of oxygen injection would increase the total cost of dredging by a modest amount, ranging from 1 to 4 percent. In contrast, hydrogen peroxide injection would increase dredging costs by 26 to 89 percent. The use of hydrogen peroxide should not be dismissed, however. First, because of its significantly greater reactivity as compared with oxygen, it may still be effective enough at lower injection rates to reduce its unit cost considerably. Second, the high reaction rates may be advantageous also in dredging situations where sediment immediate oxygen demands are high and the discharge line is relatively short. For an overall summary of Technical Report D-77-15, see abstract no. 119.

121

Ability of salt marshes to remove nutrients and heavy metals from dredged material disposal area effluents. Herbert L. Windom. Savannah, GA, December 1977. Technical Report D-77-37 (NTIS No. AD-A063 643).

Experimental raceways were constructed in a salt marsh adjacent to a confined disposal area to evaluate the use of this environment as an overland flow advanced treatment system for the effluent resulting from dredged material disposal. The research program was designed to determine the ability of the salt marsh systems to remove nitrogen, phosphorus, iron, manganese, cadmium, copper, nickel, and zinc from the effluent. While the results indicate clearly that nutrients and heavy metal concentrations in effluents from dredged material disposal areas can be reduced during passage through a salt marsh, conclusions regarding the efficiency of removal may be influenced by the size of the experimental system employed. Appendices contain: (1) field data (temperature, salinity, pH, dissolved oxygen, and turbidity) from experiments; (2) nutrient data (PO_4, NO_3, and NH_4) from experiments; (3) metal data from experiments and chemistry of sediments and *Spartina alterniflora* roots and leaves from (4) experimental raceways and (5) control stations before and after experiments. 25 references. (Author abstract modified)

122

Laboratory study of chemical coagulation as a means of treatment for dredged material. Chun-Ching Wang, Kenneth Y. Chen. Los Angeles, CA, University of Southern California, Environmental Engineering Program, December 1977. Technical Report D-77-39 (NTIS No. AD-A050 596).

Experimental work performed to evaluate the effectiveness of various flocculants in separating suspended particulates and associated chemical constituents from water columns to reduce the discharge of contaminants to receiving waters from disposal of dredged materials in confined areas is described. A literature review of the treatment of dredged material and of the flocculation mechanisms of synthetic polyelectrolytes precedes the laboratory study. The results of this and other related studies were used to develop final guidelines for the use of flocculants to treat effluent from disposal areas. Appendices contain (1) characteristics of polyelectrolyte coagulants and (2) pricings of polymers evaluated in this study. 90 references.

123

Development and application of design and operation procedures for coagulation of dredged material slurry and containment area effluent. [1]Richard H. Jones, [2]Randall R. Williams, [2]Thomas K. Moore. [1]Gainesville, FL, Jones, Edmunds and Associates, Inc.; [2]Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, September 1978. Technical Report D-78-54 (NTIS No. AD-A062 060).

Pilot plant studies were conducted to study the efficiency of polyelectrolyte coagulation of overflow from a dredged material confined disposal area at an active freshwater dredging site, and full-scale studies were conducted at the same site on the feasibility of coagulating dredged material by injecting polyelectrolytes into a hydraulic dredge pipeline. Results of the pilot plant studies show that, under the conditions tested, polyelectrolytes could be highly effective for coagulation of dredged material. Laboratory procedures were developed that can lead to the selection of the most effective coagulant, the optimum coagulant dosage, and the design parameters for a coagulation system. Examples are provided to illustrate the procedures required to design a coagulation system. Results of full-scale teste on the injection of polyelectrolytes

into a hydraulic dredge pipeline were highly variable. The high mixing rates and variability of composition of dredged material and flow rates caused a wide variation in treatment efficiency. Design examples are provided for the design of polyelectrolyte feed systems to inject polymer into a hydraulic dredge pipeline. Appendices to the report contain (1) a method for calculating mixing intensity within a pipeline and examples of those calculations, and (2) a review of equipment available for coagulation and sedimentation of dredged material. 13 references. (Author abstract)

124

Investigation of effluent filtering systems for dredged material containment facilities. Raymond J. Krizek, Joseph A. FitzPatrick, Dimitrios K. Atmatzidis. Evanston, IL, Northwestern University, The Technological Institute, Department of Civil Engineering, August 1976. Contract Report D-76-8 (NTIS No. AD-A031 368).

The functional capabilities and performance characteristics of effluent filtering systems were established by collecting all available data, reviewing the pertinent literature, and conducting about 300 laboratory and field filtration tests. Conventional, technically feasible systems were identified, new concepts (pervious dikes, sandfill weirs, and granular media cartridges) were developed, and a general methodology for the design of confined disposal facilities as solid-liquid separation systems was formulated. Appendices to this report present (1) physical and chemical data on bottom sediment and discuss (2) the correlation between turbidity and mass concentration, (3) vacuum filtration tests, and (4) solid-liquid separation technology. 102 references. (Author abstract modified) For separate sections of the report, see the following three abstracts.

125

Concepts for filtering systems. In: *Investigation of effluent filtering systems for dredged material containment facilities,* pp. 110-133. August 1976. Contract Report D-76-8.

Three different systems which appear to be applicable to the filtration of effluents from dredged material disposal areas are described. They are: pervious dikes, sandfill weirs with or without backwash, and granular media cartridges. The information provided for each system includes: (1) filter media, (2) system configuration, (3) operating conditions and performance capabilities, and (4) guidelines for the design and operation of the system. On the basis of their technical feasibility, these three systems are strong candidates for use in the clarification of supernatants from dredged material disposal areas. However, the required size of these systems may render them economically unfeasible for dredging operations in which high flow rates (approximately 1m^3/sec) are obtained continuously. For an overall summary of Contract Report D-76-8, see abstract no. 124.

126

Design guidelines. In: *Investigation of effluent filtering systems for dredged material containment facilities,* pp. 134-154. August 1976. Contract Report D-76-8.

Various design guidelines with general applicability to efficient dredged material confinement facilities are described. Several simple tentative nomographs are presented to facilitate (1) a very conservative determination of the gradation and concentration of suspended solids in disposal area effluents, (2) selection of the proper material to be used in a granular filter medium design, and (3) estimation of the effective cycle time or lifetime of a granular media filter. The types of solid-liquid separation technology applicable to the design of dredged material disposal areas include: sedimentation, chemical coagulation and flocculation, vacuum filtration, sonic screening, and granular media filtration by means of conventional equipment with automatic backwashing and granular media cartridges. For an overall summary of contract Report D-76-8, see abstract no. 124.

127

Solid-liquid separation technology. In: *Investigation of effluent filtering systems for dredged material containment facilities,* pp. D1-D34. August 1976. Contract Report D-76-8.

Descriptions are provided of (1) pretreatment of dredged material slurries by coagulation or flocculation, (2) sedimentation in disposal areas, and (3) various filter systems which could conceivably be incorporated into the design of a disposal area. Mechanized surface filtration, mechanized granular media filtration, nonmechanized surface filter systems, and electrofiltration are discussed. The characteristics and performance capabilities of these systems are reviewed, and attempts are made to give first order approximations of capital investment requirements and operational and maintenance costs. For an overall summary of Contract Report D-76-8, see abstract no. 124.

128

Feasibility of the functional use of vegetation to filter, dewater, and remove contaminants from dredged material. Charles R. Lee, Ronald E. Hoeppel, Patrick G. Hunt, Charles A. Carlson. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Effects Laboratory, June 1976. Technical Report D-76-4 (NTIS No. AD-A028 336).

The feasibility of using vegetation to filter, dewater, and remove contaminants from dredged material placed in a confined disposal area was examined, mainly on the basis of a literature review. From the information obtained, a summary was developed to provide a listing of plant species that might be propagated on disposal areas. It was concluded that the physical and chemical interactions of selected vegetation with

dredged material slurry will improve the quality of the discharge water from confined disposal areas. Appendices to the report include: (1) a list of the vegetation discussed; (2) a summary of plant species previously determined to be of potential use in slurry filtering, contaminant removal, and dredged material desiccation; (3) a discussion of the use of vegetation for slurry filtering; (4) a review of the literature on contaminant removal by vegetation; and (5) an evaluation of the dewatering of dredged material using vegetation. 137 references. (Author abstract modified)

CHAPTER 6: DESIGN, OPERATION, AND MANAGEMENT OF CONFINED DISPOSAL AREAS

Confined Disposal Facility Design, Construction, and Operation

129

Land disposal. In: *Disposal of dredge spoil: problem identification and assessment and research program development*, pp. 55-71. November 1972. Technical Report H-72-8.

Problems discussed in relation to dredge spoil disposal in confined sites include: (1) confined disposal area dike design and construction, (2) spoil improvement and utilization, (3) confined disposal area operation, (4) management and control, and (5) land use planning relationships. For an overall summary of Technical Report H-72-8, see abstract no. 22.

130

Landscape concept development for confined dredged material sites. Roy Mann, William A. Niering, Robert Sabbatini, Peter Wells. Cambridge, MA, Roy Mann Associates, Inc., December 1975. Contract Report D-75-5 (NTIS No. AD-026 684).

Guidance for landscape development of confined dredged material disposal (CDMD) facilities is provided. The principles and practices of CDMD operations and the associated constraints on and potentials to landscape development are examined, and landscape techniques directly applicable to the development of CDMD facilities are documented. This information is synthesized into planning and landscape recommendations and guidelines concerning: use of naturalized perimeters; siting proximity to natural islands; use of linear natural, complex natural, multiple modified, and modified angular land forms in designing sites; use of bulkheading, beach, and lee variants, riversides, and land-facing edges; perimeter mounding; mound silhouette control; foreground berms and mounds; setback; interior mounding; planting; and design. 26 references. Selected bibliography of 45 items. (Author abstract modified) For separate sections of the report, see the following three abstracts

131

Existing CDMD design and construction concepts: constraints and variables for landscape development. In: *Landscape concept development for confined dredged material sites*, pp. 9-49. December 1975. Contract Report D-75-5.

Pertinent concepts related to the design and construction of confined dredged material disposal (CDMD) sites are summarized in order to define how these concepts will constrain or enhance potential landscape development of the sites. The material is divided into three major sections: planning considerations, engineering considerations, and operation and maintenance of CDMD facilities. Within each section, constraints and/or variables related to landscape development are discussed and also illustrated. Accompanying tables list: incremental retention structure construction methods and constraints; retention structure problems and remedies; visual characteristics of CDMD facility components; confined disposal operation methods and landscape development constraints; and dredged material characteristics and landscape development constraints. For an overall summary of Contract Report D-75-5, see abstract no. 130.

132

Landscape architecture methodology. In: *Landscape concept development for confined dredged material sites*, pp 50-67. December 1975. Contract Report D-75-5

The principles and practices of landscape architecture as they relate to the development of confined dredged material disposal (CDMD) sites are described. The history and relevance of the profession are reviewed, and the technical and design principles applicable to CDMD development are discussed. The application of landscape architectural practices to projects and operations similar to CDMD facilities is also examined. Facilities considered include highways, strip mines, sanitary landfills, Dutch polders, and artificial islands. For an overall summary of Contract Report D-75-5, see abstract no. 130

133

Table 7: Plant list: trees and shrubs. In: *Landscape concept development for confined dredged material sites* pp. 108-156. December 1975. Contract Report D-75-5.

Three hundred twenty-nine trees and shrubs which, from a review of the relevant literature, appear to be capable of establishment on confined dredged material disposal sites and for which information regarding selection criteria was readily available are listed. The list is intended to provide only a basic framework for initial selection of potentially appropriate species, since many of the species have not yet been observed in situ. Information provided for each tree and shrub includes: botanical name, common name, zone of hardiness, height, growth rate, optimum soil condition, optimum root zone moisture, drought tolerance, salt-spray tolerance, planting techniques, foliage/trunk characteristics, and a silhouette. For an overall summary of Contract Report D-75-5, see abstract no. 130.

134

Design and construction of retaining dikes for containment of dredged material. David P. Hammer, Edward D. Blackburn. Savannah, GA, U.S. Army Engineer District, Savannah, Soils Section, August 1977. Technical Report D-77-9 (NTIS No. AD-A045 311).

Recommendations are presented for proper investigation, design, and construction of retaining dikes to aid in ensuring that these dikes will be constructed with a minimum of problems. Raising of existing dikes is covered along with the construction of new dikes. Containment capacity requirements, availability of construction materials, and prevailing foundation conditions are examined as determinants of the heights and geometric configurations of retaining dikes. Possible sources of borrow are considered. An accompanying table presents the Unified Soil Classification system. Recommendations are based upon a survey of past Corps of Engineers design and construction practices for retaining dikes and recent design procedures for construction of earth embankments. Slope stability analyses are appended to the report. 45 references. 5-item bibliography. (Author abstract modified) For separate sections of this report, see the following three abstracts.

135

[Retaining dikes: design and construction considerations.] In: *Design and construction of retaining dikes for containment of dredged material,* pp. 61-70. August 1977. Technical Report D-77-9.

Dike geometry, the effect of dike materials and foundation conditions, the effect of the method of construction employed, basic design concepts for slope stability, and the raising of existing dikes are discussed. Table 10 summarizes the Corps of Engineers typical dike sections by Corps of Engineers District, foundation material, dike material, and height, crown width, and side slope dimensions. Dike embankments are classified according to general construction methods in Table 11. For an overall summary of Technical Report D-77-9, see abstract no. 134.

136

Dike stability. In: *Design and construction of retaining dikes for containment of dredged material,* pp. 71-127. August 1977. Technical Report D-77-9.

Common causes of instability in dikes are described, and methods and procedures are recommended for analyzing dike stability with respect to inadequate foundation and/or embankment shear strength, seepage, settlement, and external erosion. The determination of material properties and field loading conditions is discussed along with the methods of analyses. Table 12 lists applicable shear strengths and recommended minimum factors of safety. For an overall summary of Technical Report D-77-9, see abstract no. 134.

137

Dike construction. In: *Design and construction of retaining dikes for containment of dredged material,* pp. 128-177. August 1977. Technical Report D-77-9.

The salient features of hauled, cast, and pumped (hydraulic fill) types of dike construction are discussed, including advantages and disadvantages, applicability, inherent effects on the dike cross section, effect of material types, and construction control. The effect of discharge facilities on the diking system and the problems caused by utility lines traversing disposal areas also are examined. Equipment commonly used in the various dike construction operations is listed in Table 13. For an overall summary of Technical Report D-77-9, see abstract no. 134.

138

Identification of objectionable environmental conditions and issues associated with confined disposal areas. Joan E. Harrison, Laurie C. Chisholm. Cambridge, MA, Arthur D. Little, Inc., September 1974. Contract Report D-74-4 (NTIS No. AD-A000 895).

Conditions and issues causing public concern about confined disposal of dredged material, identified through site visits to four U.S. Army Engineer Districts and discussions with Corps of Engineers personnel in ten other districts, are discussed in detail. Practices employed at the district level in the construction and operation of confined disposal areas are assessed in relation to measures being taken to minimize objectionable conditions. Recommendations are made on methods for mitigating or minimizing the identified problems, four specific

research areas also are cited. Appendices to the report contain: (1) details of on-site investigations; (2) the discussion guide used in determining confined disposal practices; and (3) a brief note on the possible use of disposal areas for energy production. Selected bibliography of 95 items. For separate sections of this report, see the following two abstracts.

139

Identification of objectionable conditions and issues relating to confined disposal areas. In: *Identification of objectionable environmental conditions and issues associated with confined disposal areas,* pp. 7-56. September 1974. Contract Report D-74-4.

Problematic conditions associated with effectiveness of confined disposal areas include: dike instability, seepage, dike erosion, ponding, channelization, turbidity, release of pollutants, changes in water current patterns and velocities, odor, and mosquitoes. Major issues raised in objection to confined disposal areas are ecological disruption and land-use changes. Many of the identified conditions and issues are illustrated by reference to actual conditions in the different districts studied. For an overall summary of Contract Report D-74-4, see abstract no. 138.

140

Identification of practices and regulations relating to confined disposal areas. In: *Identification of objectionable environmental conditions and issues associated with confined disposal areas,* pp. 57-92. September 1974. Contract Report D-74-4.

Practices employed at the district level in the construction and operation of confined disposal areas are assessed in relation to measures being taken to minimize conditions causing public concern about confined disposal areas. Practices relating to disposal area effectiveness, to biological, physical, and chemical changes, and to social issues are discussed. Inspection practices also are outlined. Applicable official manuals and regulations are listed. For an overall summary of Contract Report D-74-4, see abstract no. 138.

141

Practices and problems in the confinement of dredged material in Corps of Engineers projects. William L. Murphy, Timothy W. Ziegler. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Soils and Pavements Laboratory, May 1974. Technical Report D-74-2 (NTIS No. AD-780 753).

With a view to obtaining information on Corps of Engineers practices and problems in confined disposal of dredged material, visits were made in 1972 to 17 Corps of Engineers Districts in the Gulf Coast, Atlantic Coast, Pacific Coast, and Great Lakes regions. Findings relating to confined disposal area design and operation and to retaining dike design, construction, and stability are presented for many disposal sites in the different Districts. Appendices to the report give detailed descriptions of individual or groups of retaining dikes. For separate sections of this report, see the following seven abstracts.

142

Status of confined dredged material disposal. In: *Practices and problems in the confinement of dredged material in Corps of Engineers projects,* pp. 3-23. May 1974. Technical Report D-74-2.

Problems commonly encountered by Corps of Engineers (CE) Districts in relation to confined material disposal are discussed. The most important of these are difficulties in obtaining the cooperation required from local interests or sponsors and in land acquisition. Possible alternatives to lowland dredged material disposal are briefly outlined. Efforts being made by different CE Districts towards long-range planning for confined disposal are reviewed. Studies under way to determine beneficial uses of the dredged material are also described. These include construction materials, agricultural and recreational uses, industrial fill, and special applications of dredged fill material. For an overall summary of Technical Report D-74-2, see abstract no. 141.

143

[Containment area design and operation: preliminary site considerations.] In: *Practices and problems in the confinement of dredged material in Corps of Engineers projects,* pp. 24-31. May 1974. Technical Report D-74-2.

Practices of different Corps of Engineers Districts in site selection and disposal area size determination are outlined and illustrated by typical examples. Significant factors in capacity determination are the design factor, the settlement of the disposal area, and the dredged slurry discharge rate. For an overall summary of Technical Report D-74-1, see abstract no. 141.

144

[Containment area design and operation: disposal methods.] In: *Practices and problems in the confinement of dredged material in Corps of Engineers projects,* pp. 31-36. May 1974. Technical Report D-74-2.

Dredged material is most often conveyed to confined disposal facilities hydraulically, i.e., by pipeline dredge or by pumpout of hopper dredges, temporary rehandling basins, or loaded scows. Long-distance piping is also feasible. Examples of the use of these methods in different Corps of Engineers Districts

are cited. Mechanical filling of areas by dipper, bucket, and ladder dredges is employed less frequently and is usually supplementary to hydraulic methods. For an overall summary of Technical Report D-74-2, see abstract no. 141.

145

[Containment area design and operation: effluent sluicing methods.] In: *Practices and problems in the confinement of dredged material in Corps of Engineers projects,* pp. 36-45. May 1974. Technical Report D-74-2.

Methods used in various Corps of Engineers Districts for draining confined disposal facility effluent are described and illustrated by examples taken from typical installations. The different types of equipment used include outfall pipes and siphons, drop inlet sluices, box sluices or flumes, and dike filters. In the case of dike filters, the filter medium may take the form of the dike material itself or a separate filter structure may be installed in a section of the dike. For an overall summary of Technical Report D-74-2, see abstract no. 141.

146

[Containment facility operation; odor control; mosquito control.] In: *Practices and problems in the confinement of dredged material in Corps of Engineers projects,* pp. 45-62. May 1974. Technical Report D-74-2.

Factors affecting the efficiency of operation of confined disposal facilities are discussed and illustrated by examples taken from installations in different Corps of Engineers Districts. Among the factors discussed are channelization, wind, and mounding of dredged material. Methods used by the Districts to improve facility efficiency include the use of cross dikes, alternating disposal areas, spur dikes, interior drainage ditches, vegetation, energy dissipaters, filter fences, and flocculants. Efficiency is also affected by weir crest length, ponding, detention time, and freeboard, as well as by dredge pipeline size and location. Measures taken by different Districts for odor and mosquito control are outlined. For an overall summary of Technical Report D-74-2, see abstract no. 141.

147

Disposal area effluent requirements. In: *Practices and problems in the confinement of dredged material in Corps of Engineers projects,* pp. 62-64. May 1974. Technical Report D-74-2.

Effluent standards used by 16 Corps of Engineers Districts are tabulated. Practices in the Districts relating to monitoring of effluent quality are briefly discussed. Effluent monitoring is usually a contractor responsibility and in some Districts is specified in dredging contracts. For an overall summary of Technical Report D-74-2, see abstract no. 141.

148

Retaining dike design, construction, and stability. In: *Practices and problems in the confinement of dredged material in Corps of Engineers projects,* pp. 65-124. May 1974. Technical Report D-74-2.

The general features of retaining dikes constructed in Corps of Engineers Districts in the Gulf Coast, Atlantic Coast, Pacific Coast and Great Lakes regions are described. Practices employed by the Districts and their contractors relating to retaining dike design and construction are discussed. Particular reference is made to contract specifications, construction materials, and construction costs. Factors contributing to retaining dike failures are presented. These include foundation conditions, construction methods and materials, seepage, and erosion. Remedial and preventive methods that can be taken are dike inspection, control of disposal operations, and dike maintenance and repair. For an overall summary of Technical Report D-74-2, see abstract no. 141.

149

Abatement of malodors at confined dredged material disposal sites. W. Harrison, A. Dravnieks, R. Zussman, R. Goltz. Argonne, IL, Argonne National Laboratory, August 1976. Contract Report D-76-9 (NTIS No. AD-A030 597).

Numerous samples of air and dredged material were collected from seven confined disposal sites throughout the United States in an attempt to develop abatement procedures for malodors. Odorous compounds in the air samples were identified by gas chromatography/mass spectrometry, while the detection threshold, intensity, and character of the various odors were determined by experienced odor panelists using a dynamic, forced-choice-triangle olfactometer. An odor abatement strategy is proposed. Because of the almost nonexistent state-of-the-art in field-tested and operationally proven malodor abatement methodologies, the performance data resulting from field applications will prove quite valuable in technique refinement and determination of limits of applicability. The sulfur cycle in the hydrosphere is discussed in an Appendix. 47 references. For separate sections of this report, see the following two abstracts.

150

Analysis of methods of odor abatement. In: *Abatement of malodors at confined dredged material disposal sites,* pp. 101-129. August 1976. Contract Report D-76-9.

Various odor abatement treatments and methodologies are evaluated. Many of the most obvious and most cost-effective approaches fall under the term operational approach. Use of olfactory active additives should be limited to occasions in which distinct malodor problems exist and sufficient evidence indicates that the additive will mitigate the malodor. Formulations should be evaluated carefully. Treatments by ozonization

and aeration do not appear to be promising. Strategies of disinfection, antibiotic treatment, pH adjustment, microbial competition, and bioconversion are discussed. In general, malodors at European dredged material disposal sites do not constitute a significant problem. For an overall summary of Contract Report D-76-9, see abstract no. 149.

151

Odor abatement strategy. In: *Abatement of malodors at confined dredged material disposal sites,* pp. 130-137. August 1976. Contract Report D-76-9.

An odor abatement strategy is presented for handling the expected range of odor conditions at dredged material disposal sites. It consists of a series of management decisions concerning disposal site selection, site preparation, odor characterization of the sediment to be dredged, odor abatement during dredging and disposal operations, malodor abatement after disposal, and the handling of odor complaints. An accompanying chart presents the step-by-step plan for such a strategy. For an overall summary of Contract Report D-76-9, see abstract no. 149.

152

Mathematical model for predicting the consolidation of dredged material in confined disposal areas. Lawrence D. Johnson. Vicksburg, MS: U.S. Army Engineer Waterways Experiment Station, Soils and Pavements Laboratory, January 1976. Technical Report D-76-1 (NTIS No. AD A020 949).

Important parameters related to sedimentation and consolidation and their effect on the determination of confined disposal area capacities are evaluated, and interim guidelines are proposed for sizing confined disposal sites. A tentative procedure is suggested for estimating the volume-time relationships of dredged material in a flooded confined disposal area based upon simple sedimentation and consolidation theories. The procedure also includes a method for computing the consolidation of the foundation soils by standard consolidation theory. Deficiencies in existing procedures and needs for further research also are outlined. Appendices to the report contain (1) a method for evaluating sedimentation rates of suspended solids in slurry of dredged material and (2) a finite difference code for consolidation of dredged material and foundation soil. This is one of several studies conducted to develop procedures for sizing containment areas. Portions of the procedures reported herein were used to develop final guidelines contained in Technical Report DS-78-10 (abstract no. 10). 51 references. For a separate section of this report see the following abstract.

153

Capacity of containment areas. In: *Mathematical model for predicting the consolidation of dredged material in confined disposal areas,* pp. 7-36. January 1976. Technical Report D-76-1.

The total volume of the diked area available to hold dredged material is examined. Bulking factors are discussed to outline procedures for estimating the ultimate reduction in volume of dredged material and to add to the understanding of the relative behavior of different types of dredged material. Volume-time relationships are explored by examining sedimentation and consolidation theories. The settling characteristics of dredged suspensions, methods for determining sedimentation (Bosworth's method and a new method), the consolidation characteristics of dredged material and foundation soils, and four approaches for evaluating consolidation (the Lane and Koelzer method, the Terzaghi theory, Gibson's theory, and a new method) are reviewed. For an overall summary of Technical Report D-76-1, see abstract no. 152.

154

Low-ground-pressure construction equipment for use in dredged material containment area operation and maintenance--equipment inventory. Charles E. Green, Adam A. Rula. Vicksburg, MS: U.S. Army Engineer Waterways Experiment Station, Environmental Effects Laboratory, April 1977. Technical Report D-77-1 (NTIS No. AD-A041 451).

Sixty low-ground pressure vehicles were evaluated to determine their capabilities for operating in and around confined dredged material disposal areas. Available low-ground-pressure vehicles were inventoried by searching the literature and by contacting U.S. and Canadian manufacturers. The vehicles were divided into six payload classes that indirectly reflect the size of the job that the equipment can be expected to perform. Only vehicles with 1-pass vehicle cone indexes of 30 or less were included in the catalog. The soil vehicle analytical submodel of AMC-71 was used to predict vehicle performance, which was expressed in terms of go-no go and traction capability on five selected soil strengths representing many operating environments. These environments can be highly variable within a given site in terms of type of material, profile strength, presence of surface and subsurface water, and vegetal cover, thereby presenting a very harsh operational climate for vehicles or equipment. Appendices to this report describe (1) methods used to compute soft-soil vehicle performance, (2) the effects of soft soil buoyancy on vehicle cone index determination, and a vehicle catalog to assist potential users in assessing and/or selecting vehicles to perform jobs relevant to the operation and maintenance of confined disposal areas. 7 references.

155

Low-ground-pressure construction equipment for use in dredged material containment area operation and maintenance: performance predictions. William E. Willoughby. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Mobility and Environmental Systems Laboratory, August 1977. Technical Report D-77-7 (NTIS No. AD-A044 209).

The operational environments at 45 sites in nine Corps of Engineers Districts throughout the United States were characterized on the basis of soil data, and performance predictions were made for various low-ground-pressure vehicles using the collected soil data and generalized soil-vehicle relations developed at the U.S. Army Engineer Waterways Experiment Station through years of research in soil-vehicle interactions. In addition, the initial dewatering efforts in dredged material confined disposal areas at Mobile, Alabama using the Riverine Utility Craft were appraised as an indication of the direction future efforts should follow in dewatering and consolidating dredged material confined disposal facilities. The appendix to this report provides a data summary and site description for sampled confined disposal areas. 7 references. (Author abstract modified) For separate sections of the report, see the following two abstracts.

156

[Methodology for predicting vehicle performance.] In: *Low-ground-pressure construction equipment for use in dredged material containment area operation and maintenance: performance predictions*, pp. 15-22. August 1977. Technical Report D-77-7.

The method employed to make performance predictions for various low-ground-pressure vehicles for use in confined disposal area operations consists, in part, of experimental relations for vehicle drawbar pull and motion resistance in terms of measured soil strength parameters. The standard measure of soil strength used in vehicle relations is obtained with the Waterways Experiment Station cone penetrometer and is expressed as either cone index for coarse-grained soils or rating cone index for fine-grained soils. For an overall summary of Technical Report D-77-7, see abstract no. 155.

157

Predictions of vehicle performance. In: *Low-ground-pressure construction equipment for use in dredged material containment area operation and maintenance: performance predictions*, pp. 22-29. August 1977. Technical Report D-77-7.

Three basic work functions are identified as necessary for adequate operation and maintenance of confined disposal areas: survey and reconnaissance, trenching, and earthmoving. The anticipated work performance of 18 vehicles representing a broad spectrum of vehicles with various propulsion systems and a range of weights and sizes is evaluated on a go-no go basis in confined disposal areas. Survey and reconnaissance vehicles are only available to a limited extent. Many smaller lightweight vehicles are capable of making single passes in an area but cannot perform work requiring multiple passes. Conventional trenching machines and earthmoving equipment require firm soils on which to operate and consequently were predicted to negotiate only about 50 percent of the areas sampled. Unique or specialized types of equipment designed specifically for soft-soil operations were predicted to negotiate more than 95 percent of the areas sampled and could perform functions other than survey and reconnaissance. For an overall summary of Technical Report D-77-7, see abstract no. 155.

158

Sizing of containment areas for dredged material. Suzanne E. Lacasse, T. William Lambe, W. Allen Marr. Cambridge, MA, Massachusetts Institute of Technology, Constructed Facilities Division, Department of Civil Engineering, October 1977. Technical Report D-77-21 (NTIS No. AD-A050 038)

A rational method for sizing confined disposal areas is presented together with three interim guidelines for selecting the parameters required by the method. The results of this study as well as other separate procedures were used to develop the recommended sizing procedure contained in Technical Report DS-78-10, 'Guidelines for Designing, Operating, and Managing Dredged Material Containment Areas.' The technique developed from this study aims at improving the bulking factor sizing method which is in use and takes into account (a) the properties of the channel sediment to be dredged, (b) the behavior of the dredged material in the disposal site, and (c) the components of the dredging operation that affect volume of sediment dredged. The major unknown in the method is the void ratio of the dredged material; laboratory sedimentation tests on channel sediment help predict void ratio versus depth and time in dredged material. Pertinent values of the dredging operation were reviewed, the behavior of several types of dredged material was studied, and the prediction methodology was applied to four disposal sites--two in Cleveland Habor (Ohio), the Branford Harbor upland disposal site (Connecticut), and the Anacortes disposal site (north of Seattle, Washington). In general, comparisons of the predicted versus measured void ratio distribution of dredged material and the predicted versus observed performance of confined disposal areas were satisfactory. Appendices describe (1) seven confined disposal sites in use by the Corps of Engineers (Branford Harbor upland disposal site, Anacortes, Capsante, James River-Windmill Point, Browns Lake, Upper Polecat Bay, and Cleveland Harbor), and (2) notations used in the report. 25 references. (Author abstract modified) For separate sections of this report, see the following two abstracts.

159

Confined disposal area sizing methodology. In: *Sizing of containment areas for dredged material,* pp. 18-32. October 1977. Technical Report D-77-21.

The methodology devised for predicting the size of confined disposal areas filled with dredged material, an extension of the Massachusetts Institute of Technology marsh creation sizing method, establishes an interrelationship between measurable soil characteristics and dredging operation parameters. A material balance equation determines the effective volume of solids entering the confined disposal area and yields the required containment volume. The methodology incorporates the following parameters: (1) volume of sediment to be dredged; (2) in situ void ratio of sediment; (3) overdredging factor; (4) loss factors in the dredging and disposal operation; (5) rate of filling the confined disposal area versus effluent detention time; (6) average void ratio versus depth (and total unit weight) of dredged material at a given time; and (7) foundation settlement. For an overall summary of Technical Report D-77-21, see abstract no. 158.

160

Table 1: Summary of sizing methods used by selected Corps of Engineers district offices and research agencies. In: *Sizing of containment areas for dredged material,* p. 19. October 1977. Technical Report D-77-21.

The sizing methods employed by 12 Corps of Engineers district offices and research agencies in the United States and Japan are listed. The majority of the offices consulted use a refined but still empirical bulking factor technique in which sizing depends on a factor defined in terms of the grain size of the sediment. The sizing factors indicated by each organization express the ratio of the volume occupied by the dredged material in the confined disposal area to the volume of sediment removed from the channel bottom. For an overall summary of Technical Report D-77-21, see abstract no. 158.

161

Investigation of containment area design to maximize hydraulic efficiency. Los Angeles, CA, Brian J. Gallagher and Company, May 1978. Technical Report D-78-12 (NTIS No. AD-A056 525)

Methodologies for improving the hydraulic efficiencies of dredged material confined disposal areas were investigated, and general guidelines for the proper design and operation of disposal areas and their inlet and outlet arrangements were developed. The study consisted of: (1) a review of published literature and technical reports; (2) site visits and field tests at 10 active disposal areas to obtain operational data; (3) development of a mathematical model and computer programs to predict flow patterns and retention times of different area configurations; and (4) formulation of a general methodology for the design of efficient confined disposal areas. Sites were located in the Baltimore, Charleston, Galveston, Mobile, Norfolk, Philadelphia, Portland, Savannah, Seattle, and Vicksburg Corps of Engineers Districts. It was concluded that the addition of spur dikes to increase the effective length-to-width ratio, prevent short-circuiting between inlet and outlet, and retard wind-induced circulation was the most economical method of maximizing hydraulic efficiency, particularly for large, square-shaped areas. Other recommendations include the specification of minimum ponding depths based on selective withdrawal principles and the design of long, rectangular weirs to prevent flow concentration and resuspension problems. Appendices present (1) the review of CE Districts disposal operations, (2) the mathematical analysis of basin hydraulics; (3) the weir and flow characteristics literature review; and (4) the economic analysis. 76 references. (Author abstract modified) For separate sections of this report, see the following three abstracts.

162

[Mathematical model for determining the influence of basin hydraulics.] In: *Investigation of containment area design to maximize hydraulic efficiency,* pp. 48-61. May 1978. Technical Report D-78-12.

A theoretical approach was developed to predict the flow field in a homogeneous shallow basin with through-flow and superimposed wind. The major physical parameters include through-flow, wind stress, eddy viscosity, bottom topography, and disposal area geometry. A general solution for the transport stream function was obtained for a rectangular basin of constant depth with uniform wind and arbitrary locations of the inflow pipe and outflow weir. Solutions for particular cases were then obtained, and methods were advanced for determining the effects of wind on the velocity field and the distribution of retention times. Justifications of applicability and detailed mathematical derivations are appended. For an overall summary of Technical Report D-78-12, see abstract no. 161.

163

[Factors affecting the discharge of supernatants in confined disposal areas.] In: *Investigation of containment area design to maximize hydraulic efficiency,* pp. 62-77. May 1978. Technical Report D-78-12.

The influence of weir design on the effective discharge of supernatants from confined disposal areas is discussed. The manner in which supernatants are released from a sedimentation basin affects the velocity and density distributions of the water column in front of the weir, which then influences the quality of the discharged supernatants. The selective withdrawal concept of controlling the quality of these waters was chosen for initial investigation, and the preliminary findings and recommendations are presented. The application of the selective withdrawal concept to weir design was evaluated in more detail in a later study (see Technical Report D-78-18,

abstract no. 165) and final guidelines are given in Technical Report DS-78-10 (abstract no. 10). Specific attention is given to the factors which affect ideal settling conditions in a sedimentation basin. These include the physical and chemical characteristics of the suspension, the occurrence of short circuiting, the resuspension of sediment, the nonuniform deposition of sediment, and the occurrence of turbulence in the basin. For an overall summary of Technical Report D-78-12, see abstract no. 161.

164

[Economic considerations for maximizing hydraulic efficiencies of disposal areas.] In: *Investigation of containment area design to maximize hydraulic efficiency,* pp. 78-86. May 1978. Technical Report D-78-12.

Economic factors which will help the designer minimize disposal costs while maximizing hydraulic efficiencies are discussed. An overall concept of evaluating disposal projects for minimum total costs is presented, followed by an illustration of the manner in which outside dike shapes and sizes affect the unit cost of disposal operations. Optimum internal configurations to maximize hydraulic efficiencies at minimum unit costs per cubic yard are then developed. Additional details and generalized analytical equations are included in an Appendix, which focuses on configurations for longitudinal and transverse spur dikes. For an overall summary of Technical Report D-78-12, see abstract no. 161.

165

Weir design to maintain effluent quality from dredged material containment areas. Thomas M. Walski. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, May 1978. Technical Report D-78-18 (NTIS No. AD-A056 062).

A procedure is developed for designing and operating the weir to maintain good effluent quality, given a flow and dredged material type. Stratified-flow and sediment-transport models were investigated to describe the depth of withdrawal, velocity profile, and effluent suspended solids concentration, given a concentration profile and flow. Field data on these parameters were collected at three sites--Yazoo River, Mississippi and Fowl River and Oyster Bay, Alabama. The Waterways Experiment Station's selective withdrawal model developed by Bohan and Grace, modified to fit observed data, was selected as the basis of the design procedure. Using this model, nomograms were developed for the design procedure for silt and saltwater clays and for freshwater clays. The nomogram relates the flow, weir length, ponding depth, and effluent suspended solids concentration. The designer manipulates these four variables until he reaches a satisfactory balance between weir length and ponding depth, based on his design flow and effluent goal. Modified versions of these nomograms are presented in final guidelines contained in Technical Report DS-78-10. Sharp-crested, rectangular, or shaft-type weirs are recommended. Guidance for operation of the weir for special applications also is presented. Appendices to the report give (1) equations to relate density and solids concentration and (2) withdrawal depth and velocity profile models. 94 references. (Author abstract)

166

An investigation of physical, chemical, and/or biological control of mosquitoes in dredged material disposal areas. Final report. W. Bruce Ezell, Jr. Charleston, SC, The Citadel, The Military College of South Carolina, August 1978. Technical Report D-78-48 (NTIS No. AD-A061 311).

Detailed studies were conducted on the ecology and control of mosquitoes developing within dredged material disposal sites near coastal locations in several U.S. Army Corps of Engineers (CE) Districts. Primary study sites were located in the Charleston District. All known literature citing an association between mosquitoes and disposal areas was reviewed, and a national survey of the attitudes and opinions of personnel from local mosquito abatement districts, a selected CE Districts, and State vector control agencies was analyzed using national and regional controls. Studies on factors affecting the ecology of all arthropods within disposal sites were initiated, including soil and water characterizations. An arthropod successional pattern was postulated based on soil weathering patterns. Eight different successional stages based on soil patterns were identified. Emergence traps were used to study arthropods associated with dredged material of varying ages, and studies were made comparing adult mosquito activity with selected weather variables. Site visitations were conducted to eight CE Districts, where additional observations and collections were made. Results of limited tests using two insect growth regulator compounds are presented. More extensive tests were conducted using physical control measures, including the use of rim ditching techniques and the Riverine Utility Craft. A listing of plant successional patterns, plant species associated with mosquito larvae, standing crop estimations, and species composition data from disposal sites is presented. Ornithological studies considered the species composition of birds utilizing disposal sites. Appendices present (1) a review of the interagency perspectives on mosquito conditions and control in confined dredged material disposal sites, (2) a list of significant data by regions, (3) a list of all mosquito species known to be associated with dredged material disposal sites, (4) a summary of the site visitations to the CE Districts, (5) a discussion of the vegetation analysis of diked dredged material disposal sites, and (6) a discussion of the occurrence of avian species within dredged material disposal sites. 71 references. (Author abstract modified. For separate sections of this report see the following abstracts.)

167

Arthropod successional patterns within dredged material disposal sites. In: *An investigation of physical, chemical, and/or biological control of mosquitoes in dredged material disposal areas,* pp. 54-115. August 1978. Technical Report D-78-48.

Studies were conducted to elucidate possible successional patterns of plants, soil, and arthropods that could be related in turn to mosquito patterns. Soil samples from several disposal sites with a history of producing mosquitoes were analyzed for chemical content, and a picture of soil weathering stages was proposed on the basis of these and other tests. Eight different successional stages based on soil patterns were studied. Emergence traps were used to sample the arthropod fauna associated with these stages. All of the data indicate that arthropods were using dredged material in greater numbers than had been expected. A table of all arthropods collected from disposal sites is presented. As a result of this study, field workers can be trained to recognize the various dredged material stages, and these can then be related to mosquito potential. For an overall summary of Technical Report D-78-48, see abstract no. 166.

168

Ecology of mosquitoes associated with dredged material disposal sites. In: *An investigation of physical, chemical, and/or biological control of mosquitoes in dredged material disposal areas,* pp. 116-177. August 1978. Technical Report D-78-48.

The results of field trips made to a large variety of dredged material disposal sites in various CE districts are presented and discussed. Individual sections cover the following topics: (1) prevalence of larval habitats for mosquitoes within dredged material disposal areas; (2)survey of larval mosquitoes associated with disposal areas; (3) chemical characteristics of water from larval habitats within disposal areas; (4) adult mosquito surveys within disposal areas, and (5) influence of weather on adult mosquito light trap collections from disposal areas. For an overall summary of Technical Report D-78-48, see abstract no. 166.

169

Possibilities for biological control of mosquitoes within dredged material disposal sites. In: *An investigation of physical, chemical, and/or biological control of mosquitoes in dredged material disposal areas,* pp. 183-191. August 1978. Technical Report D-78-48.

Various operative or possible future methods of biological control of mosquito populations at dredged material confined disposal sites are examined. Classically, biological control agents are composed of diseases (pathogens and parasites) and predators. The main groups of pathogens and parasites are nematodes, bacteria, fungi, viruses, and protozoa; the major predators are vertebrates, invertebrates, or plants. The use or release of sterile, incompatible, or male mosquitoes with adverse genetic translocations is generally referred to as genetic control, an approach which has shown excellent promise in areas isolated from other breeding areas. Most potential control organisms cannot yet survive and/or be released into disposal sites. However, the future for biological control remains promising. For an overall summary of Technical Report D-78-48, see abstract no. 166.

170

Feasibility of Pinto Island as a long-term dredged material disposal site. T. Allan Haliburton, Patrick A. Douglas, Jack Fowler. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Effects Laboratory, December 1977. Miscellaneous Paper D-77-3 (NTIS No. AD-A050 331).

A cooperative effort by the U.S. Army Engineer District, Mobile (MDO) and the U.S. Army Engineer Waterways Experiment Station (WES) to illustrate application of technology developed by the Dredged Material Research Program (DMRP), administered by WES, in solution of field element problems is described. The study sought to determine if a site on Pinto Island, near Mobile, Alabama, could be used as a long-term disposal facility to contain maintenance dredging material from the Mobile River. Survey data, foundation characterization, and background data were provided by MDO, while evaluation and assessment were conducted by WES. Using DMRP-developed concepts, plans were developed for optimum use of the site, including details of sequential construction, dredged material dewatering, and productive use of dewatered dredged material. Two alternate disposal area configurations to provide adequate capacity through the year 2007 and through the year 2019 are proposed for consideration by MDO. For each alternative, total costs of disposal area construction, operation, and maintenance are estimated to be approximately $0.40 per cubic yard of storage capacity. The appendix presents a preliminary design for the Pinto Pass dikes. (Author abstract)

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Methodology for design of fine-grained dredged material containment areas for solids retention. Raymond L. Montgomery. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, December 1978. Technical Report D-78-56.

Procedures for designing fine-grained dredged material confinement areas to provide adequate retention of suspended solids so that required effluent suspended solids levels can be met are provided based on field and laboratory investigations. Field studies were performed to obtain samples of channel sediment and dredged material for laboratory tests, determine suspended solids levels of dredged discharges and disposal area effluents, and develop profiles of suspended solids

versus depth for the disposal areas. It was found that grab samples taken from the channel bottom are sufficient for performing sediment characterization and settling tests; it also was demonstrated that settling tests performed in an 8-in.-diam. column are satisfactory for defining dredged material settling behavior within a confined disposal area. Methodology is presented for designing new disposal areas for suspended solids retention and the suspended solids retention potential of existing disposal areas. The designs call for suspended solids removal by the process of gravity sedimentation, allowing discharge of carrier water from the confined disposal area. Design methods for saltwater and freshwater sediments are included. Appendices to this report contain (1) column settling test data and (2) example design calculations. 35 references. (Author abstract modified)

172

Assessment of certain European dredging practices and dredged material containment and reclamation methods. K. d'Angremond, J. Brakel, A. J. Hoekstra, W. C. H. Kleinbloesem, L. Nederlof, J. de Nekker. Rotterdam, The Netherlands, Adriaan Volker Dredging Co., December 1978. Technical Report D-78-58.

A study was made of dredging practices, reclamation methods, and environmental effects of dredging in Western Europe, by visiting more than twenty ports and six countries and discussing pertinent matters with knowledgeable authorities. A remarkable similarity of dredging practices, reclamation methods, and dredging equipment was noted among the European ports. The productive land use of dredged material was a common goal. Contaminatin problems existed or were potential to various degrees at all ports. All were aware of the need for continued researh into dredging practices and reclamation methods and of the need to intensify research in the area of environmental effects. The need for regionaland worldwide legislation to control contamination and other adversese environmental effects also was universally recognized. Conventional and special dredges, other equipment, and methods of classifying the material to be dredged are described in detail. Disposal methods and practices are described and resulting environmental impacts are discussed. Methods include disposal in the ocean, rivers, lakes, pits, and confined and unconfined land areas. Methods of dewatering dredged material and reclaiming and utilizing confined disposal areas are presented. Agricultural uses of disposal areas are discussed and research results of laboratory and field experiments oncntaminant uptake by plants are presented. Other productive uses of dredged material and/or disposal areas are outlined. Appendices to the report contain: (1) a description of the European ports visited, (2) Permanent Internatinal Association of Navigation Congresses (PIANC) sediment classification system; (3)discussion of increasing percent solids in hoppers through the use of polymers and hydrocyclones; (4) a discussion of the dehydration of clay minerals; (5) discussion of the development of bearing capacity of hydraulically transorted sands; (6) physical, chemical, and microbiologicalripening of soils in polders, (7) a discussion of research into heavy metals in the Dutch delta, (8) the composition of heavy metals in Rotterdam Harbor mud; (9) a glossary of terms; and (10) notations. 21 references.

Dewatering and Densifying Dredged Material

173

Feasibility study of hydrocyclone systems for dredge operations. W. G. Tiederman, M. M. Reischman. Stillwater, OK, Oklahoma State University, Office of Engineering Research, July 1973. Contract Report D-73-1 (NTIS No. AD-766 212).

The development of processes which will clarify the water and concentrate the small suspended solids in dredge spoil would make spoil transport more efficient, would permit the use of smaller sites, and would decrease the environmental impact of dredge operations. The feasibility of using hydrocyclone separators for the concentration and clarification of dredge spoil has been studied using six dredge spoil samples, two clay slurries, and one sand. The effect of particle size, viscosity of fluid, and inlet solids on the effectiveness of the hydrocyclones was determined. Attempts also were made to increase performance by chemically flocculating the solids upstream of the hydrocyclones. While the clarification and concentration performance of the hydrocyclones was good on low solids content clay slurries, the performance ranged from average to poor on the spoil samples. Reasons for the poor performance are discussed. The feasibility of using hydrocyclones to recover sand and gravel while rejecting fine silt also was studied. The hydrocyclone successfully recovered sand from the full range of spoils and may be applicable for classifying solids in dredge spoil. Appendices to this report contain: (1) tabulation of results, (2) detailed procedural descriptions, (3) a description of the sink-vortex clarifier and summary tables of thickening tests; (4) theoretical analyses and mathematical derivations; (5) a data sheet for hydrometer analysis; and (6) sample calculations. 10 references. (Author abstract modified)

174

Demonstration of a methodology for dredged material reclamation and drainage. Carl W. Garbe, David D. Smith, Sri Amerasinghe. San Francisco, CA, Dames & Moore, September 1974. Contract Report D-74-5 (NTIS No. AD-A000 896).

Results are given of a field demonstration conducted to evaluate the effectiveness of a method for reducing the volume and improving the physical characteristics of dredged material for disposal in confined areas. The method consists of periodic mechanical agitation of newly deposited dredged material slurry by a tracked vehicle in order to prevent the formation of a desiccation crust and thereby accelerate the evaporation of water by natural processes. Appendices

describe (1) other demonstrations of the slurry conditioning methodology and (2) meteorological monitoring data. Note that later DMRP research indicates the procedure demonstrated has limited application (see later information on effectiveness of agitation in Technical Report D-77-10). 8 references.

175

Laboratory study of aeration as a feasible technique for dewatering fine-grained dredged material. Stillwater, OK, Environmental Engineering Consultants, Inc., December 1976. Contract Report D-76-10 (NTIS No. AD-A035 673).

The feasibility of employing aeration as a means of hastening the drying of fine-grained dredged material was investigated analytically and experimentally. Laboratory experiments were conducted on two materials in which 3-ft and 6-ft cylindrical columns of slurry were aerated at various airflow rates employing initial moisture contents from 200 to slightly over 300 percent. It was shown that bubbling of diffused air into the slurry increased the rate of moisture loss. Statistical analyses of these data led to an empirical formula for predicting moisture content from initial moisture content, depth, and unit airflow rate for the two materials. The equation provided reasonable predictions for results obtained in another laboratory-scale slurry pit. The high cost of using diffused air to enhance drying under field conditions is discussed, and recommendations are made for further field demonstration and design criteria studies. 12 references. (Author abstract modified)

176

State-of-the-art applicability of conventional densification techniques to increase disposal area storage capacity. Stanley J. Johnson, Robert W. Cunny, Edward B. Perry, Leslie Devay. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, April 1977. Technical Report D-77-4 (NTIS No. AD-A041 452).

Conventional techniques (including those used in industrial processes) for densifying dredged material by dewatering to increase disposal area storage capacity and to improve the engineering characteristics of the material are evaluated on a judgmental basis without the benefit of laboratory or field research. Conventional geotechnical treatment methods and technical and economic evaluation of surcharge loading, vertical sand drains, underdrainage, chemical additives and mechanical working techniques for densifying dredged material are reviewed. Cost comparisons of various dewatering and densification techniques for dredged material are evaluated which illustrate the factors involved in each technique and the magnitude of densification costs, but which exclude cost effects of local conditions. Densification by loading, by drainage, and by desiccation are the methods evaluated and are discussed solely from the viewpoint of obtaining additional storage capacity in disposal areas. It is concluded that dredged material in disposal areas is similar to materials successfully treated by conventional soil mechanics and foundation engineering practices, but the practicality of using coventional densification techniques to increase disposal area capacity depends more on economic than on technical considerations. Appendices include: (1) a description of sediments; (2) a summary of conventional dewatering and densification techniques; and (3) calculations for the economic evaluation of densification techniques. 123 references. For separate sections of this report, see the following three abstracts.

177

Engineering properties of dredged material. In: *State-of-the-art applicability of conventional densification techniques to increase disposal area storage capacity,* pp. 14-39. April 1977. Technical Report D-77-4.

Engineering properties of dredged material placed in confined disposal areas are evaluated conceptually by considering samples of dredged material of known properties in sedimentary environments similar to those found in disposal areas. Engineering properties of material from dredging sites in the Delaware River, Toledo Harbor, Buffalo Harbor, Cleveland Harbor, Mobile Harbor (Upper Polecat Bay) and the Mississippi River Gulf Outlet are discussed. The placement of material, formation of crust, effect of organic matter, water content, Atterberg limits, densities, effect of distance of material from inlet pipe or overflow weir, void ratio, consolidation characteristics, and shear strengths are discussed in terms of their impact on material densification. Dredged materials are compared with soils stabilized by conventional techniques. It appears that conventional engineering experience is applicable to densification of dredged material, although there are important limitations to be considered. For an overall summary of Technical Report D-77-4, see abstract no. 176.

178

Description of conventional densification techniques. In: *State-of-the-art applicability of conventional densification techniques to increase disposal area storage capacity,* pp. 40-48. April 1977. Technical Report D-77-4.

Conventional physical and mechanical densification-dewatering methodologies are described. Physical methods include loading techniques, drainage techniques, desiccation by vegetation, and desiccation by capillary wicks. These treatment methods are identified in Table 13 according to benefits achieved. Mechanical methods are surface drainage, surface trenching, reworking of dredged material, material mixing, and a Dutch technique which increases the speed of biological and chemical processes by which the material is converted to more stable soil. Less information is available on mechanical methods, so they are reviewed in greater detail. For an overall summary of Technical Report D-77-4, see abstract no. 176.

179

Chemical densification techniques. In: *State-of-the-art applicability of conventional densification techniques to increase disposal area storage capacity,* pp. 49-63. April 1977. Technical Report D-77-4.

Chemical densification techniques used by the phosphate and aluminum industries to dewater their waste slimes and other chemical treatment methods were studied to determine their applicability to dewatering and densification of dredged materials. Based on the experience of the phosphate and aluminum industries, it appears that flocculants could be used to expedite the initial sedimentation of clay-sized dredged material. Other chemical techniques such as addition of quicklime and calcium carbide are shown to work but at an expense so great as to probably outweigh the benefits *derived. For an overall summary of Technical Report* D-77-4, see abstract no. 176.

180

Effects of mechanical agitation on drying rate of fine-grained dredged material. T. Allan Haliburton, Gary N. Durham, Kirk W. Brown, Robert F. Peters, Thomas B. Delaney, Jr. Vicksburg, MS: U.S. Army Engineer Waterways Experiment Station, Environmental Effects Laboratory; September 1977. Technical Report D-77-10. (NTIS No. AD-A044 843)

The results of theoretical and experimental studies concerning the effect of continuous mechanical agitation on the evaporative drying rate of fine-grained clay slurries and dredged material are presented. Studies included a theoretical investigation of factors controlling the evaporation from soils slurries, a small-scale *controlled-agitation experiment during a period* of low evaporative demand, a large-scale controlled agitation experiment during a period of high evaporative demand, and a 6-month field demonstration of periodically mixing surface crust with underlying very wet dredging material at the Upper Polecat Bay disposal area in the Mobile, Alabama District. Based on the results of these studies, mechanical agitation on either a continuous or a periodic basis to dewater fine-grained dredged material is not recommended. Appendices to the report contain: (1) test data, (2) pictorial documentation, and (3) *water content data from the large-scale agitation experi*ment. 19 references.

181

Freeze-thaw enhancement of the drainage and consolidation of fine-grained dredged material in confined disposal areas. Edwin J. Chamberlain, Scott F. Bloom. Hanover, NH: U.S. Army Cold Regions Research and Engineering Laboratory, Foundations and Materials Research Branch, October 1977. Technical Report D-77-16. (NTIS No. AD-A046 400)

Fine-grained dredged material obtained from disposal sites in the Great Lakes region was subjected to controlled freeze-thaw cycling in a special laboratory consolidometer. Volume changes and permeabilities were observed after full consolidation and freeze-thaw cycling for applied pressures in the range of 0.93 to 30.73kPa. Laboratory results are discussed. The application of the phenomenon of overconsolidation by freezing and thawing to disposal sites is examined, and site management procedures are suggested. The process appears to be particularly adaptable to regions of cold winters where material frost penetrations of more than 1m can be obtained, but it can also be made applicable to regions of more moderate winters, such as the Great Lakes region, by sequentially depositing and freezing dredged material during the winter months. Analyses of the costs of trenching, pumping, and snow removal are appended to this report. 22 references. (Author abstract modified)

182

Feasibility study of general crust management as a technique for increasing capacity of dredged material containment areas. Kirk W. Brown, L. J. Thompson. College Station, TX: Texas A&M University, Texas A&M Research Foundation, October 1977. Technical Report D-77-17. (NTIS No. AD-A047 509)

The influence of meteorological conditions and the physical, chemical, and mineralogical properties of fine-grained dredged material on the formation of crusts resulting from evaporative drying in confined disposal areas was evaluated. Bulk samples of materia were collectec from confined disposal areas at Philadelphia, Toledo, Norfolk, and Mobile. *Methods of managing a confined disposal area to maximize* crust formation also were studied. The moisture content, suction, conductivity, and unit weight relationships developed *through this study will be used to develop guidance for the* management of confined disposal areas to maximize their capacity through dewatering. Monthly maps of the mean net and gross pan evaporation over the continental United States were developed, and examples are given of their utilization to predict water loss and densification as a function of management practices. Appendixes to the report contain: (1) a *dredged material sample field report,* (2) a monthly meteorological record for the period of November 1975 through May 1976, (3) the drainage program, and (4) data on special equipment used. 49 references. For a separate section of this report, see the following abstract.

183

Rate of crust formation. In: *Feasibility study of general crust management as a technique for increasing capacity of dredged material containment areas,* pp. 68-71. October 1977. Technical Report D-77-17.

The rate at which a dry crust forms and methods of crust management are examined. Figures showing average pan and net evaporation for the continental United States for

January, March, May, July, September, and November are used to demonstrate the necessity for proper drainage of confined disposal areas. The initial part of any management scheme must be a program to insure the rapid surface drainage of rainwater. Removal of the crust to a depth of 1 or 1.2m once it has dried to that depth would seem to be the best approach. For an overall summary of Technical Report D-77-17, see abstract no. 182.

184

Containment area management to promote natural dewatering of fine-grained dredged material. Michael J. Bartos. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Effects Laboratory, October 1977. Technical Report D-77-19 (NTIS No. AD-A047 514).

The results of a study of dredged material dewatering concepts conducted to promote natural dewatering of fine-grained dredged material are presented. The study design consisted of interviews with personnel from Corps of Engineers Districts, visits to confined disposal areas, and the use of technology being developed by the Corps of Engineers Dredged Material Research Program. The findings indicate that little is being done to dewater fine-grained dredged material confined on land. Based on the engineering judgment of study participants, four general guidelines for confined disposal area management were formulated. Confined disposal area management can be planned to facilitate the installation of some of these systems during or immediately following a disposal operation. 18 references. (Author abstract modified) For a separate section of this report, see the following abstract.

185

Concepts for confined disposal area design, operation, and management. In: *Containment area management to promote natural dewatering of fine-grained dredged material,* pp 23-79. October 1977. Technical Report D-77-19.

Management concepts which promote dredged material dewatering by the natural processes of gravity drainage, evaporation, and transpiration and which are adaptable to the incorporation of alternative dewatering techniques are presented in the form of specific guidelines for dredged material dewatering. The first guideline is concerned with the separation of sand and gravel from the fine material during the dredging operation. Surface water management is the subject of the second guideline, which suggests that water be left ponded within the area throughout the disposal operation and thereafter be removed quickly to initiate evaporation at the earliest time. The third guideline presents concepts for optimizing evapotranspirative dewatering by scheduling dredging before hot, dry weather, by placing dredged material in lifts not greater than 0.3m thick, and by using vegetation to transpire water from the dredged material. Alternative dewatering techniques, for use during the rainy season or during the winter, are the subject of the fourth guideline. (Author abstract modified) For an overall summary of Technical Report D-77-19, see abstract no. 184.

186

Field study to determine the feasibility of electro-osmotic dewatering of dredged material. Charles E. O'Bannon. Tempe, AZ, November 1977. Miscellaneous Paper D-77-2 (NTIS No. AD-A048 566).

Research conducted to determine the feasibility of using electro-osmosis to dewater in-place dredged material economically and within a reasonable period of time is described. The theory of electro-osmosis states that the rate of flow through soil is proportional to the voltage gradient and the cross-sectional area. The constant of proportionality is not dependent upon soil permeability, but does vary with interstitial water salinity. The relationship is similar to Darcy's law for flow through a porous medium under the influence of a hydraulic gradient. A preceding laboratory study showed that electro-osmosis does dewater dredged material at relatively low-voltage gradients. Dewatering proceeded rapidly during the first several weeks of laboratory testing, but then declined, due to drying at anodes and concentration polarization at electrodes. During subsequent field testing, at the Upper Polecat Bay Disposal Area in the Mobile District, the water content of the dredged material was not changed, although water was removed from the dredged material by the system. It appeared that surface infiltration at the anodes and desiccation cracks replaced water removed by the electro-osmosis system. Based on the water-removal rates, the installation of railroad rails and slotted steel pipe electrodes on the 6.1-meter spacing was the most efficient. However, the cost per cubic meter of water removed for this test section was $21.20. Coke-breeze anodes and chlorine resistant electrodes and slotted steel pipe cathodes are recommended for future implementation, particularly in saltwater environments. 11 references. (Author abstract modified)

187

An evaluation of progressive trenching as a technique for dewatering fine-grained dredged material. Michael R. Palermo. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Effects Laboratory, December 1977. Miscellaneous Paper D-77-4 (NTIS No. AD-A052 687).

The results of an investigation of the effects of progressive trenching on dredged material dewatering and densification are presented. The study consisted of an initial field and laboratory testing program, construction of a surface drainage system within the disposal area using a progressive trenching approach, evaluation of trenching equipment including the Riverine Utility Craft or RUC, and a field instrumentation and monitoring program. Use of the progressive trenching approach showed that construction of surface drainage systems within disposal areas is operationally feasible. Effects of the progressive trenching efforts were evaluated by monitoring

dredged material surface elevations and dredged material groundwater elevations within the study area. Field data indicated that the surface drainage system was effective in lowering the dredged material groundwater table. An average surface settlement of approximately 0.75 ft was achieved throughout the study area. Economic evaluations indicated that progressive trenching operations were economically feasible with both comparatively low unit cost and favorable benefit/cost ratios. Appendices to the report contain: (1) site history and characteristics; (2) dredged material test data summaries; (3) observation well data; and (4) field settlement data. 30 references. (Author abstract modified)

188

Prediction of volumetric requirements for dredged material containment areas. Myron L. Hayden. Stillwater, OK, Oklahoma State University, August 1978. Technical Report D-78-41 (NTIS No. AD-A062 481).

The results of a three-phase study undertaken to determine the volumetric requirements of a confined disposal site filled with fine-grained dredged material are presented. The phases consisted of: (1) evaluating previous work and formulating a new prediction methodology based on modified consolidation theory and standard weight-volume relationships used in geotechnical engineering; (2) developing the proposed prediction methodology, and (3) correlating the volume increase predicted by the proposed methodology with the rate of volume increase measured under field conditions. The creation of a computer program (SIZE), based on the prediction methodology developed during the study, for the purpose of evaluating the effect of various input variables on the gain in available storage volume also was included in the final phase. Verification of the methodology was provided by results obtained from a comprehensive testing program established at the 34.4-ha Upper Polecat Bay disposal site of the U.S. Army Engineer District, Mobile, Alabama, by a testing program created during this study, and by the development of a laboratory column sedimentation-consolidation procedure in addition to the correlation of results obtained from remolded and undisturbed consolidation testing. The objective of this study was accomplished by evaluating the interrelationship of the different variables and their effect on the change in potential storage volume with time. Appendices to this report contain: (1) the proposed procedure to be used in laboratory testing for the SIZE methodology, (2) the detailed procedure for determining the consolidation characteristics of dredged material, (3) the listing of the computer program SIZE, (4) specific flowcharts for SIZE, and (5) output from computer analysis of example problems. 38 references. (Author abstract modified) For a description of size, see the following abstract.

189

Description of computer program SIZE and sample applications. In: *Prediction of volumetric requirements for dredged material containment areas,* pp. 187-262. August 1978. Technical Report D-78-41.

The purpose, organization, and capabilities of the computer program SIZE are discussed, and the formats specified for data input and output are described. This program was designed for applicability over a broad range of conditions, and the results obtained from it are site-specific. The initiation of the dredging process is the starting point, the program ends when either an equilibrium volume has been reached or additional dredged material has been put into the site. Its ability to develop an optimized site operational scheme based on any given dewatering technique(s) in conjunction with the specified dredging schedule makes the program a valuable design aid. Several example problems demonstrating the method required to represent a real problem mathematically are provided as illustrations of the correct method of utilizing SIZE. For an overall summary of Technical Report D-78-41, see abstract no. 188.

190

Dredged material dewatering field demonstration at Upper Polecat Bay disposal area, Mobile, Alabama. T. Allan Haliburton. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, December 1978. Technical Report D-78-59.

This report summarizes field studies conducted at the Upper Polecat Bay disposal area in the Mobile District to evaluate various methods of dewatering/densifying fine grained dredged material. The tests were conducted to determine three factors: technical feasibility, operational practicality, and cost effectiveness. Techniques evaluated were surface trenching, vacuum wellpoints (conventionally and wind powered), capillary wicks, sand slurry injection, mechanical agitation, underdrains, electro-osmosis, and vegetation. Individual, more detailed reports exist on the surface trenching, mechanical agitation, and electro-osmosis studies. Use of surface trenching was found to be technically feasible, operationally practical, and cost effective. Technical feasibility of using wind powered generation systems to provide electrical power at remote disposal area locations was neither positively proved nor disproved. However, problems encountered during the demonstration indicate that the concept may be operationally impractical until the state-of-the-art of the equipment is improved. Dewatering with conventionally powered vacuum wellpoints was found to be technically feasible and operationally practical, but not cost effective when compared to other alternatives. Capillary wicks were not found to be technically feasible as the amount of dewatering produced was minimal. Use of sand slurry to hydraulically fracture fine grained dredged material and produce internal drainage layers was found to be technically feasible and operationally practical. Because of the small scale of the study, cost effectiveness could not be properly assessed.

Periodic mechanical agitation and mixing of the upper crust with underlying subcrust was found to accelerate the rate of dredged material surface subsidence, and thus the procedure was technically feasible, as well as cost effective. However, the procedure is effective in only the upper few inches of the material and, until equipment can be developed to mix the material at depth, the procedure was rated operationally impractical. Use of underdrains, including gravity and vacuum-assisted underdrainage, and gravity and vacuum-assisted seepage column consolidation was found to be technically feasible, operationally practical, and cost effective. The technical feasibility of using electro-osmosis was neither positively established nor refuted, but results suggest that unless the system is installed prior to disposal, and fresh water dredged material is dewatered, dewatering will be technically ineffective, operationally impractical, and not cost effective. Attempts to artificially establish vegetation for dewatering purposes were unsuccessful and no definitive information could be gained on this technique. Based on the results of the demonstration, improved surface drainage techniques are recommended to promote dredged material dewatering and densification. These concepts should prove satisfactory in a great majority of instances and have the advantages of being fairly simple in concept and low in cost. The procedure can be augmented by underdrains. Other techniques would have extremely limited application. Four appendices are attached: A. Initial Site Foundation Investigation and Laboratory Test Data; B. Linear Shrinkage Test Method and Data for Dredged Material; C. Site Dredged Material Laboratory Test Data; and D. Test Data from Vacuum Wellpoint Demonstration.

Disposal Area Reuse

191

Perimeter dike raising with dewatered fine-grained dredged material at Upper Polecat Bay Disposal Area, Mobile, Alabama. [1]T. Allan Haliburton, [1]Jack Fowler, [2]J. Patrick Langan. [1]Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory; [2]Mobile, AL, U.S. Army Engineer District, Mobile, August 1978. Miscellaneous Paper D-78-3 (NTIS No. AD-A061 353).

Use of dewatered fine-grained dredged material for large-scale perimeter dike raising was evaluated by a cooperative field demonstration between the U.S. Army Engineer District, Mobile and the Dredged Material Research Program Disposal Operations Project and Productive Uses Project at the Upper Polecat Bay Disposal Area, Mobile, Alabama. The report provides data on design and construction methodology for cost-effective removal of the dewatered fine-grained dredged material and its productive use in disposal site perimeter dike raising, thus completing the cycle of operations required for effective confined disposal area operation and management. Based on the field demonstration, it was determined that: (1) fine-grained dredged material of high plasticity may be used successfully in large-scale dredged material disposal site perimeter dike-raising activities once the material has been dewatered; (2) the cost of dike raising with the dewatered fine-grained dredged material was less than estimated for use of offsite borrow even though the demonstration site had good haul access; and (3) the three different methods evaluated for dewatered dredged material borrow removal and the three methods evaluated for perimeter dike raising all were found to be technically feasible and operationally practical. It is recommended that Corps of Engineers field elements and other interested agencies seriously consider using dewatered fine-grained dredged material for large-scale perimeter dike-raising activities, following the construction procedures described and evaluated in this report. 8 references. (Author abstract modified)

192

Regional landfill and construction material needs in terms of dredged material characteristics and availability. Richard Reikenis, Victor Elias, Edwin F. Drabkowski. Towson, MD, Green Associates, Inc., May 1974. Contract Report D-74-2 (NTIS No. AD-780 750).

Present and potential landfill needs and construction material needs within 100 miles of major dredging activities were evaluated in five coastal regions: Gulf States, South Atlantic, North Atlantic, Great Lakes, and Pacific Coast. Matrix analysis was employed to evaluate existing, projected, and potential landfills and also to provide quantitative assessments of demand for dredged materials. Much of the information on which the report is based was collected from contacts with knowledgeable groups in the different regions and from interviews with Corps of Engineers district offices. Appendices to the report reproduce: (1) selected answers to letters of inquiry; (2) memoranda of Corps of Engineers district visits; (3) selected memoranda of telephone contacts; and (4) an econometric site evaluation model. 138-item bibliography. For a separate section of this report, see the following abstract.

193

Availability and utilization of dredged material as construction material. In: *Regional landfill and construction material needs in terms of dredged material characteristics and availability*, pp. 167-178. May 1974. Contract Report D-74-2.

From an analysis of statistics on the demand for sand and gravel for use as concrete aggregates and on the life expectancy of existing sources, it appears that shortages are developing near major urban centers. The possibilities and problems of using dredged material as a replacement for sand and gravel are discussed. The engineering characteristics of dredged material also are discussed in relation to its possible use in construction materials. For an overall summary at Contract Report D-74-2, see abstract no. 192.

194

Containment area facility concepts for dredged material separation, drying, and rehandling. Charles W. Mallory, Michael A. Nawrocki. Columbia, MD, Hittman Associates, Inc., October 1974. Contract Report D-74-6 (NTIS No. AD-A002 605).

Results are given of a study aimed at developing alternative dredged material confined disposal area concepts and design guidelines for separating, drying, or dewatering solids and removing them from the site for utilization. Appendices to this report contain: (1) additional detailed data on liquid-solids separation, (2) ASTM standards for sand and gravel, and (3) notes on other fine-grained material drying/dewatering techniques that have been investigated. 39 references. For separate sections of this report, see the following four abstracts.

195

[Dredged material separation, sand and gravel beneficiation, and economic aspects of separation and recovery.] In: *Containment area facility concepts for dredged material separation, drying, and rehandling,* pp. 16-40, 60-81, 169-188. October 1974. Contract Report D-74-6.

Equipment and processes potentially applicable to liquid-solids separation of dredged materials are discussed under the headings: sieves and screens, settling, spiral classifiers, coagulation and flocculation, inclined tube settlers, centrifugal separation (hydrocyclones and swirl concentrators), filters, and flotation. Facilities, equipment, and processes applicable to dredged material separation, drying, and rehandling, particularly in relation to sand and gravel recovery and fine-grained material separation and dewatering, also are discussed. The design and operating characteristics of commercially available equipment for sand and gravel beneficiation are described. This equipment includes: scalping pump boxes, vibrating screens, hydraulic scalpers and classifiers, spiral classifiers, and conveyors for handling and dewatering. Finally, costs (1973-74 basis) of equipment and operations applicable to separation and beneficiation, secondary dredging, and hydraulic thickening are presented. Based on these costs, the economics of sand and gravel recovery, silt recovery and transportation, and clay disposal are outlined. For an overall summary of Contract Report D-74-6, see abstract no. 194.

196

Sand and gravel separation. In: *Containment area facility concepts for dredged material separation, drying, and rehandling,* pp. 82-111. October 1974. Contract Report D-74-6.

Design concepts for separation basins, including multiple/compartmented basins and floating separation compartments, are presented. To remove the separated sand and gravel, draglines could be used with compartmented basins and small dredges in the case of conventional basins and floating settlers. Alternatives to the use of basins for sand and gravel separation are hydraulic scalping of the full dredge flow, hydraulic scalping coupled with hydrocyclones, and hydrocyclones alone to separate sand if the dredged material is composed mainly of fines. In hydraulic separation, the number of required scalping and classification tanks can be reduced by the use of conventional clarifier or thickener tanks to accomplish an initial splitting of the sand and gravel. For an overall summary of Contract Report D-74-6, see abstract no. 194.

197

Fine-grained material separation and handling. In: *Containment area facility concepts for dredged material separation, drying, and rehandling,* pp. 112-158. October 1974. Contract Report D-74-6.

Following a discussion of treatment of dredged slurry in conventional containment basins or by secondary dredge removal, design and requirements of secondary dredge and storage basins, including silt and clay retention basins, are examined. Conditions favorable to the use of coagulants and flocculants and also inclined tube settlers are outlined. For an overall summary of Contract Report D-74-6, see abstract no. 194.

198

Dewatering and utilization of fine-grained material. In: *Containment area facility concepts for dredged material separation, drying, and rehandling,* pp. 159-168. October 1974. Contract Report D-74-6.

Drying and dewatering techniques that have been investigated and appear promising for application to the fine grained fraction of dredged material solids include: gravity drainage, rehandling, surface working, vacuum pumping, electroosmosis, and thickening followed by vacuum filtration. Each of these techniques is described briefly, and their applicability to different particle sizes is considered. Potential uses for the dried fine-grained material as fill material, in agricultural applications, and in building materials are noted. For an overall summary of Contract Report D-74-6, see abstract no. 194.

199

Legal, policy, and institutional constraints associated with dredged material marketing and land enhancement. Ronald C. Wakeford, Donald Macdonald. McLean, VA, American Technical Assistance Corp. December 1974. Contract Report D-74-7 (NTIS No. AD-A006 595).

Legal constraints which limit the range of possible uses of dredged material, the laws and regulations controlling its sale or donation, and the official and public attitudes which can affect such actions are discussed in Section I of the report. Section II enumerates pertinent Federal statutes, regulations, and treaties, Corps of Engineers regulations, and State laws and codes. Coverage is through 1972. Procedures for updating the material in this report are outlined. Appendices to this report contain: (1) key word lists used in searches; (2) Environmental Protection Agency enforcement conferences excerpts; (3) press clippings; (4) hierarchy of laws and regulations of the Federal and State governments; and (5) questionnaires. Classified bibliography of 50 items.

200

Classification and engineering properties of dredged material. Michael J. Bartos. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Effects Laboratory, September 1977. Technical Report D-77-18 (NTIS No. AD-A047 768)

Data on the classification and engineering characteristics of dredged material are presented. This information was obtained from Corps of Engineer Districts and from published reports, and a program of sampling and testing of material to be dredged was undertaken. The discussion of standard soil properties tests is very basic. Five soil classification systems are examined. The engineering properties of 10 specimens of dredged material, compacted to simulate anticipated field conditions or potential productive uses (i.e., landfill, construction materials, etc.), are presented and discussed in a very basic manner to show that dredged material is not simply the waste product of dredging but is in fact composed of various types of soil. The engineering properties of dredged material in confined disposal areas, as reported by other investigators, are reviewed. Appendices to the report contain: (1) a glossary of terms, (2) an explanation of sample numbers, (3) classification test data, and (4) a list of abbreviations used. 31 references. For a separate section of this report, see the following abstract.

201

Productive use of dredged material: land-use categories, dredged material landfills, and dredged material for construction. In *Classification and engineering properties of dredged material*, pp. 107-113. September 1977. Technical Report D-77-18.

The concept of using dredged material gainfully is reviewed. The potential for the productive use of dredged material is discussed in terms of the dredged material properties determined during this study. The discussion focuses upon the physical and engineering properties of dredged material and does not consider pollution status. Land uses are subdivided into urban, environmental, economic, and resource related groupings. Dredged material landfills constructed of slurry and of rehandled material are considered. The use of dredged material alone as well as in combination with other materials also is examined. For an overall summary of Technical Report D-77-18, see abstract no. 200.

202

Identification of alternative power sources for dredged material processing operations. C. E. Parker, D. Pal, K. F. Vodraska, J. B. Ciani. Port Hueneme, CA, Naval Construction Battalion Center, Civil Engineering Laboratory, November 1977. Technical Report D-77-32 (NTIS No. AD-A048 312)

A screening and selection procedure is provided for the engineer designing a dredged material processing system that allows him to decide which natural form of energy (or combination), if any, should be chosen to power the system. The evolution, development, and energy conversion feasibility of wind power for driving pumps and electric generators, solar radiation for conversion to thermal and electrical energy, and hydraulic power to drive electrical generators are discussed. Wind power potential for nine sites and hydraulic power potential for nine regions are examined, and information pertinent to determining the availability of solar energy under given conditions is provided. Appendices include (1) wind power analysis methodologies and conversion systems, (2) solar energy conversion processes; (3) hydraulic power analysis methodologies and conversion systems, (4) data and power potential for selected locations, and (5) information sources. 32 references. (Author abstract modified)

203

Feasibility study of vacuum filtration systems for dewatering dredged material. Bruce W. Long, Dominic J. Grana. St. Louis, MO, Ryckman/Edgerley/Tomlinson & Associates, Inc., February 1978. Technical Report D-78-5 (NTIS No. AD-A053 773).

The feasibility of dewatering dredged material by vacuum filtration was investigated in the laboratory using samples from six disposal areas: Penns Neck Spillway, Apalachicola Bay, Mobile Bay, Toledo Harbor, Craney Island, and Browns Lake. Investigations of particle size distribution, specific resistance to filtration (using the Buchner funnel), filter leaf studies, and bench scale vacuum filtration studies were conducted. The samples collected were diluted to between 8 and 25 percent solids by weight and chemically conditioned for the various testing procedures. Seven chemical coagulants were investigated. The results attained indicated that dredged material from the different sites could be effectively dewatered to 45 to 60 percent solids (depending on the site) using lime dosages of 7 to 10 percent of the solids in the sample. Field studies of a pilot plant are recommended to evaluate further the operating parameters of vacuum filtration under actual conditions. Appendices present particle size distribution data on the various samples and data summaries for the Buchner funnel studies. 8 references. (Author abstract modified) For other sections of this report, see the following two abstracts.

204

Principles of vacuum filtration. In: *Feasibility study of vaccum filtration systems for dewatering dredged material,* pp. 16-18. February 1978. Technical Report D-78-5.

Techniques for vacuum filtration of sludges resulting from primary and secondary sewage treatment and from process industry operations are described, and the basic principle of continuous rotary vacuum filtration is illustrated in an accompanying figure. Filter design and operating variables are discussed in detail. Vacuum filtration of industrial wastes and sewage sludges is considered superior to other mechanical dewatering techniques for many applications due to the continuity of the process, the higher capture of solids, efficiency in dewatering difficult biological and industrial waste sludges, and proven cost effectiveness and performance. For an overall summary of Technical Report D-78-5, see abstract no. 203.

205

Economic analysis of vacuum filtration methods for dewatering dredged material. In: *Feasibility study of vaccum filtration systems for dewatering dredged material,* pp. 117-119. February 1978. Technical Report D-78-5.

Factors involved in the evaluation of the feasibility of vacuum filtration for dewatering dredged material are identified, with special emphasis placed on the importance of individual disposal site cost benefit comparisons. The benefits resulting from the application of vacuum filtration include increasing the useful life of a given site by reducing the initial volume of dredged material requiring disposal and the volume of water remaining with the dredged material in the disposal site after surface material forms a crust. Costs associated with vacuum filtration of dredged material prior to disposal in a land disposal site include the installed capital investment for filter and associated equipment, as well as operation and maintenance expenses. The cost of a vacuum filter installation at the Lower Polecat Bay disposal area is discussed, based on a dredging rate of 25,000 cubic yards per day. This illustration shows that although vacuum filtration may be technically feasible, this approach to treatment should not be selected until economic feasibility is established on a case-by-case basis. For an overall summary of Technical Report D-78-5 see abstract no. 203.

206

Development of procedures for selecting and designing reuseable dredged material disposal sites. Thomas F. Raster, Harbinder S. Gill, David C. Steuernagel, David J. Lipiro. Buffalo, NY: Acres American Inc., June 1978. Technical Report D-78-22 (NTIS No. AD-A058 422).

A logical step-by-step methodology for site selection and design is presented. The method provides the capability for handling anything from a single disposal site serving a single dredging location to an entire dredging program involving several dredging locations and disposal sites. The methodologies identify pertinent legal, environmental, and technological factors that influence selection of candidate disposal sites and determine their suitability as reuseable or nonreuseable sites. The methodology includes site design and operating recommendations and a preliminary costing procedure to enable evaluation of alternative disposal options for each site and cost modifications of an entire dredging program. Numerous numerical examples are provided to assist in applying the procedures to a particular case. Although the report promotes reuseable disposal sites, management procedures for extending the life of nonreuseable sites of a conventional nature also are discussed in detail for those situations where reuseable sites are inappropriate or economically unfeasible. The results of this study were used in part to develop final guidelines for selecting and designing reuseable disposal sites. Appendices contain: (1) a comparison of possible secondary dredges, (2) the list of equipment suppliers contacted; and (3) development and sources of equations used in the report. 44 references. (Author abstract modified)

207

Needs and areas of potential application of Disposal Area Reuse Management (DARM). Michael R. Palermo. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, June 1978. Technical Report D-78-27 (NTIS No. AD-A057 920).

Nine Corps of Engineers Districts were surveyed for needs and areas of potential application of Disposal Area Reuse Management (DARM). Under this concept, disposal areas are regarded as collection and processing sites where dredged material is rehandled within the site or removed totally, thereby increasing or restoring capacity for subsequent disposal. Where responsibility for providing disposal sites lies with the government, DARM is generally viewed as a viable alternative to acquisition of additional sites if technical constraints can be resolved and economic feasibility can be determined. It was found that critical shortages of confined disposal capacity now exist in many areas throughout the country. However, Districts are generally reluctant to restore sites through DARM in cases where provision of disposal sites is is viewed as the sole responsibility of the local sponsor. The technical feasibility of full-scale application of DARM is demonstrated by the success of ongoing programs in the Philadelphia and Sacramento Districts involving predominantly coarse grained material in a ready-to-use condition. 27 references. (Author abstract modified) For a separate section of this report, see the following abstract.

208

Potential application of DARM. In *Needs and areas of potential application of Disposal Area Reuse Management (DARM),* pp. 30-38. June 1978. Technical Report D-78-27.

Factors affecting the potential large-scale implementation of Disposal Area Reuse Management (DARM) are discussed. Large-scale implementation of DARM programs may relieve shortages of disposal area capacity in selected areas, thereby reducing or delaying requirements for acquisition of additional lands for disposal areas. The degree of potential application available is dependent upon: (1) evaluation of DARM alternatives in planning and design of confined disposal areas; (2) expansion of ongoing DARM programs; (3) solution of technical constraints through ongoing research; (4) identification of suitable markets and/or uses for dredged material products; and (5) specific changes in present policy toward dredged material disposal and disposal area ownership. For an overall summary of Technical Report D-78-27, see abstract no. 207.

209

A new concept for dredged material disposal. Michael R. Palermo, Raymond L. Montgomery. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Effects Laboratory, February 1976. Miscellaneous Paper D-76-15.

Acquisition of suitable land for confined disposal of dredged material has become increasingly difficult due to rising cost and public objection to land use for this purpose. This problem could be minimized if the useful life of disposal areas could be extended, allowing reuse over longer periods. The concept of disposal site reuse involves the reduction in volume and/or actual removal of dredged material from the disposal area for use elsewhere, thereby allowing additional placement of dredged material at the site. Multiple advantages can be realized through site reuse: (1) a permanent reusable site would be provided for the maintenance dredging at a centralized location; (2) operation of reusable sites would be environmentally compatible because facilities could be properly planned and engineered, greater control is possible and site operation is better supervised; (3) valuable resources could be reclaimed from the dredging operation and donated or sold for productive use; and (4) expense and public objection to new disposal areas would be greatly reduced due to reduction in excessive land-use requirements. For site reuse to be successful, the material must be in a usable condition, potential uses must be identified, and site management must be tailored to meet requirements for continued reuse. Research completed to date has identified methods of separating, drying, and rehandling dredged material, legal and policy constraints regarding marketing and disposition of the material, and potential use of dredged material for landfill and construction purposes. The feasibility of site reuse as established through completed and ongoing research must be established by field studies which are currently being initiated. Ultimate widespread use of reusable disposal areas will depend upon future constraints placed on conventional disposal methods and upon economic and environmental considerations.

210

First steps toward achieving disposal area reuse. Raymond L. Montgomery, Michael R. Palermo. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Effects Laboratory, April 1976. Miscellaneous Paper D-76-16.

The objectives of research on disposal area reuse are simply to develop procedures for maintaining a dredged material disposal area for an indefinite period while providing environmentally acceptable disposal operations. The reusable dredged material disposal area is a collection and processing site where valuable portions of the dredged material are made available for productive use while unusable material is, if necessary, treated and disposed of. Methods and procedures must provide for continuous or periodic removal of dredged material for use or storage elsewhere in order to increase the life expectancy of the facility. In the Mobile Bay area, plans for expansion of disposal areas have been abandoned in some cases because of objections from local residents and environmental constraints. Thus, the need for maximizing the useful life of existing sites in this area is pressing. This paper presents results from a field study in the Mobile Bay area outlining the first steps taken toward the development of a reusable disposal area. Plans and concepts are discussed regarding the long range planning required to maintain use of sites for indefinite periods. This paper does not present a panacea for dredged material disposal problems because it is not available now nor will it be in the future. Each reusable disposal area will have to be developed based on its own needs and local environment.

CHAPTER 7: EFFECTS OF MARSH AND TERRESTRIAL DISPOSAL

211

Spoil disposal on marshland. In: *Disposal of dredge spoil: problem identification and assessment and research program development,* pp. 72-75. November 1972. Technical Report H-72-8.

Since marsh zones are valuable components of the estuarine ecosystem, Federal, State and local conservation agencies are restricting spoil disposal on marshland. Methods of minimizing the detrimental effects of marsh disposal are discussed. For an overall summary of Technical Report H-72-8, see abstract no. 22.

212

The effects of smothering a *Spartina alterniflora* salt marsh with dredged material. Robert J. Reimold, Michael A. Hardisky, Patrick C. Adams. Brunswick, GA, University of Georgia, Marine Extension Service, July 1978. Technical Report D-78-38 (NTIS No. AD-A063 366).

The impact of smothering short form *Spartina alterniflora* in Glynn County, Georgia, with three types of dredged material (coarse sand, sand and clay mixed, and clay), at six depths (8, 15, 23, 30, 61, and 91 cm), and at different stages of plant growth (February, July, and November) was examined. Corrugated metal pipes (0.9-m diam) were sunk into the marsh and used as containers for dredged material. The impact of disposal was evaluated over two growing seasons. Plant and macroinvertebrate (crabs and snails) response, plant performance (biomass), dredged material chemistry, and plant invasion of experimental enclosures are discussed. *Spartina alterniflora* was able to penetrate up to 23 cm of each type of dredged material and exhibited biological growth and production nearly equal to that in undisturbed marsh. These depths, within the elevation range of the marsh, indicate that accurate tidal and elevational data should be collected before disposal on a marsh and that deposition should not exceed the elevational limit of the existing marsh. While smothering operations can offer an alternative to disposal, the technique cannot be considered proven and must be approached with care. Appendices to this report contain (1) the analysis of variance for marsh smothering enclosure and control areas, (2) a graphic representation of dependent variables for marsh smothering experimental and control areas; (3) the analysis of variance for biomass and culm density in marsh smothering enclosures; and (4) marsh smothering plant invasion 2 X 2 frequency tables. 26 references. (Author abstract modified)

213

Environmental impact of dredging and disposal on the Upper Mississippi River at Crosby Slough. John W. Held. La Crosse, WI, University of Wisconsin, River Studies Center, August 1978. Miscellaneous Paper D-78-2 (NTIS No. AD-A061 847).

A study designed to assess the environmental impact associated with land disposal of sandy material on the aquatic habitat around Island 117, located in Navigation Pool 8, Upper Mississippi River is described. The study was conducted during the period June 1974 to June 1975. Various biological, physical, and chemical variables were measured before, during, and after the discharge of dredged material. Disposal activity at Island 117 during 1974 produced no measurable effects on these variables. Changes recorded in benthos biomass were due to natural production phenomena rather than to the effects of deposition of dredged material. A general increase in mean particle size of sediments at the 50 sample sites was noted from early to late summer, but the trend was not consistent, and these changes were probably due to natural sedimentation phenomena. If 1974 disposal activities affected water quality in the study area, these effects were masked by the natural background variation in the variables examined. Turbidity and nitrite-nitrogen, which were increased by dredged material disposal in 1973, were not significantly altered during 1974. The Appendix presents the raw data obtained from the study. 13 references. (Author abstract modified)

214

A survey of potential medical and veterinary diseases at habitat development field sites. John W. Simmers. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, July 1978. Miscellaneous Paper D-78-1 (NTIS No. AD-A061 845).

A three-phase literature survey of selected potential medical and veterinary diseases at the Miller Sands Marsh and Upland Habitat Development Site (Columbia River, Oregon), the Bolivar Peninsula Marsh and Upland Habitat Development Site (Galveston Bay, Texas), and the Windmill Point Marsh Development Site (James River, Virginia) is described. The first phase involved the listing of animal species (both fish and wildlife) associated with the particular habitat development sites. The second phase identified known diseases of human or veterinary importance potentially associated with each animal on the list and the role that the animal plays in the transmission of the disease. The third phase served to define the actual localized and Statewide occurrence of the diseases listed. The results of the survey are presented in three tables according to the following column headings: host; vector or intermediate host; disease; role of host in disease; pathogen; hosts of economic significance; human infections per year; average for State; likelihood of occurrence; and appended notes. 14-item bibliography.

215

Mineral cycling in salt marsh-estuarine ecosystems. Ecosystem structure, function, and general compartmental model describing mineral cycles. Douglas Gunnison. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Effects Laboratory, January 1978. Technical Report D-78-3 (NTIS No. AD-A052 737).

A nutrient and heavy metal cycling study of marsh-estuarine ecosystems was undertaken. A resulting compartmental model outlining pathways of mineral cycling within the marsh-estuarine ecosystem is described. Approaches used in the study included literature surveys and discussions with authorities in marsh-estuarine ecology. Nutrient and heavy metal cycles within the marsh-estuarine ecoysystem are discussed. Carbon, nitrogen, phosphorus, sulfur, and selected heavy metals are included. Information from allied research fields was used to supplement direct information sources. The appendix contains summary tables for the general model of the marsh-estuarine ecosystem. 259 references. (Author abstract modified)

216

A hydroponic study of heavy metal uptake by selected marsh plant species. Final report. Charles R. Lee, Thomas C. Sturgis, Mary C. Landin. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Effects Laboratory, June 1976. Technical Report D-76-5 (NTIS No. AD-A033 224).

An experimental greenhouse study of heavy metal uptake by eight marsh plants is reported. *Cyperus esculentus, Scirpus validus, Spartina patens, Scirpus robustus, Distichlis spicata, Triglochin maritima, Spartina alterniflora*, and *Spartina foliosa* were grown in chemically controlled hydroponic solutions containing three concentrations of heavy metals. The heavy metals studied were zinc, cadmium, nickel, lead, and chromium, each at a concentration of 0.0, 0.5, and 1.0ppm. The findings indicate that *Cyperus esculentus, Spartina patens, Distichlis spicata*, and *Spartina alterniflora* appear to have more potential than other marsh plants studied in taking up zinc, cadmium, and nickel. Lead and chromium accumulated in the roots of all species with very little translocation into plant tops. In many aspects the obtained data present a worst case situation, and they should be interpreted accordingly. The chemical data used to prepare figures in the main text are included in the appendix to the report. 16 references. (Author abstract modified)

217

Trace and toxic metal uptake by marsh plants as affected by Eh, pH, and salinity. R. P. Gambrell, V. R. Collard, C. N. Reddy, W. H. Patrick, Jr. Baton Rouge, LA, Louisiana State University, Center for Wetland Resources, December 1977. Technical Report D-77-40 (NTIS No. AD-A050 914).

The effect of substrate physical and chemical conditions on the uptake of trace and toxic metals by marsh plants was studied under greenhouse and laboratory conditions. Reasonably successful methods were developed for growing marsh plants in the experimental systems. The successful methods as well as procedures which were not successful are discussed, along with techniques for overcoming experimental difficulties. Based on the results of this research, it is concluded that pH, salinity, and redox potential do affect the plant availability of trace and potentially toxic metals. It is recommended that these physicochemical properties be considered in selecting environmentally sound disposal methods for contaminated dredged sediments. Management practices to reduce metal availability of certain trace metals subsequent to disposal of contaminated dredged material appear feasible. 75 references. (Author abstract modified)

218

Prediction of heavy metal uptake by marsh plants based on chemical extraction of heavy metals from dredged material. Charles R. Lee, Richard M. Smart, Thomas C. Sturgis, Robert N. Gordon, Mary C. Landin. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Effects Laboratory, February 1978. Technical Report D-78-6 (NTIS No. AD-A054 129).

A field and laboratory study investigated the extent of heavy metal absorption and uptake by salt marsh plant species from dredged material and examined techniques of chemical extraction of heavy metals to predict the concentration of these metals in marsh plants subsequently grown on the dredged material. Extensive field sampling of marsh plants and dredged material from Corps of Engineers disposal sites was conducted along the East and Gulf Coasts of the United States. Marsh plant species included *Spartina alterniflora, Spartina patens*, and *Distichlis spicata*. Four procedures for extracting heavy metals from soil were evaluated, including

water soluble, ammonium acetate exchangeble, dilute acid extractable, and DTPA extractable samples. DTPA extraction of heavy metals gave the best correlations with actual heavy metal concentrations in marsh plants. The other procedures were limited to one or two heavy metals and only one of the three marsh plant species studied. Results indicate that uptake of zinc, copper, cadmium, and to some extent lead and chromium can be predicted using a DTPA extraction procedure. Prediction of plant uptake of nickel or mercury was not possible in this study. Appendices present prediction equation and verification data on the contents of heavy metals in plant and dredged material samples. 48 references. (Author abstract modified)

219

Field bioassay test for detecting contaminant uptake from dredged material by marsh plants. Paul L. Wolf, John L. Gallagher, Carlos H. Pennington. Sapelo Island, GA, University of Georgia Marine Institute, December 1978. Miscellaneous Paper D-78-6 (NTIS No. AD-A066 802).

A field method designed to evaluate the potential for contaminant uptake by marsh plants growing on dredged material was developed. Techniques were field tested in Georgia and Oregon marshes. Indigenous marsh plants were grown on three types of contaminated dredged material and were compared with control plants grown on native soils. *Distichlis spicata, Salicornia virginica, Spartina alterniflora*, and *Spartina patens*were used for study in Georgia, and *Deschampsia cespitosa, Distichlis spicata, Carex lyngbyei*, and *Salicornia virginica*, in Oregon. Although uptake of contaminants by marsh plants was not demonstrated definitively, the bioassay experiment test appears to be an efficient and relatively inexpensive technique for identifying potential problems concerning contaminant uptake by marsh plants prior to dredged material disposal. Certain procedural refinements are necessary before this method will be ready for general field application. 20 references. (Author abstract modified)

CHAPTER 8: HABITAT CREATION AND DEVELOPMENT

Aquatic Habitat Development

220

Seagrass literature survey. Joseph C. Zieman, Kent W. Bridges, C. Peter McRoy. Charlottesville, VA, University of Virginia, Department of Environmental Sciences, January 1978. Technical Report D-78-4 (NTIS No. AD-A054 480).

Published literature and unpublished documents up to mid-1977 pertaining to seagrasses are listed. There are more than 1,500 entries. Broad scientific subject areas that relate to seagrasses, such as anatomy, ecology, morphology, taxonomy, and physiology, are considered together with more specific factors, such as substrate selectivity, water quality, productivity, colonization, effect of physical energy (waves, tidal currents, sediment transport), propagation, and tolerance to disturbance. The bibliography is divided into two main reference sections consisting of a bibliographic citations section and a keyword index section. The appendices consist of two supplementary reference sections--an author index section and a source index section. (Author abstract modified)

221

Habitat development field investigations, Port St. Joe Seagrass Demonstration Site, Port St. Joe, Florida. Summary report. [1]Ronald C. Phillips, [2]Mary K. Vincent, [2]Robert T. Huffman. [1]Seattle, WA, Seattle Pacific College; [2]Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, July 1978. Technical Report D-78-33 (NTIS No. AD-A058 733).

To investigate the feasibility of propagating seagrass on dredged material, transplants of shoal grass (*Halodule wrightii*) were made at Port St. Joe, Florida. Using the plug technique, two sizes of plugs were removed from a natural meadow and planted on subaquatic, unconfined coarse-grained dredged material at three different spacing intervals. Shoal grass was chosen for its suitability to local substrate conditions and because of its tolerance to environmental extremes. Many of the transplants demonstrated a significant amount of growth before the project failed nearly 13 months after planting. Best growth was obtained with 375-cm^2 plugs planted on 0.9-m centers. The reason for the project failure is not known, but it is hypothesized that the factors involved included stresses from an unusually cold winter, exposure, erosion, sedimentation, variations in water quality, and heavy surf. Seagrass propagation on dredged material has promise, but recommendations are made for further field studies. Photographs of shoal grass transplants are appended. 20 references. (Author abstract modified)

Marsh Development

222

Underground biomass dynamics and substrate selective properties of Atlantic coastal salt marsh plants. John L. Gallagher, F. Gerald Plumley, Paul L. Wolf. Sapelo Island, GA, The University of Georgia Marine Institute, December 1977. Technical Report D-77-28 (NTIS No. AD-A055 761)

Work on the dynamics of the underground portion of salt marsh species in Maine, Delaware, and Georgia, the characterization of marsh soils, and experiments on the substrate selective properties of several of the species are summarized. The species studied included: *Borrichia frutescens, Carex paleacea, Distichlis spicata, Eleocharis obtusa, Juncus gerardi, Juncus roemerianus, Phragmites communis, Salicornia virginica, Spartina alterniflora, Spartina bakeri, Spartina cynosuroides, Spartina patens,* and *Sporobolus virginicus*. Chapters contain information on: (1) underground biomass profiles and dynamics; (2) comparison of tidal marsh soils, (3) response of plants to an impulse of ammonium nitrate, (4) plant growth on three types of dredged material; and (5) a bioassay approach to studying plant growth. Methodologies that can be used to determine which marsh plants will be likely to do well on various kinds of dredged material and when a marsh established on dredged material approaches natural conditions are described. The report provides recommendations on the use of dredged material and plant species and emphasizes the advisability of a field bioassay prior to dredging. 25 references.

223

Primary productivity of minor marsh plants in Delaware, Georgia, and Maine. Robert J. Reimold, R.A. Linthurst. Brunswick, GA, University of Georgia, Marine Extension Service, November 1977. Technical Report D-77-36 (NTIS No. AD-A051 164).

The importance of common species of salt marsh plants inhabiting wetlands in Maine, Delaware, and Georgia is summarized. An evaluation of the ecologic significance of the plants is based upon plant density, biomass, detrital flux, mortality, and comparisons of techniques for measuring productivity. The data are important in reaching decisions relative to the deposition of dredged material in these coastal wetland systems. Appendices contain: (1) monthly climatological data; (2) tidal data; (3) monthly mean values for living aerial biomass, dead aerial biomass, live-to-dead ratios, living stem densities, and individual living stem weights for the angiosperms sampled; and (4) a summary of the instantaneous rate of detritus flux, amount of material disappearing, estimated net aerial primary production, and estimated mortality for the angiosperms sampled. 118 references. (Author abstract modified)

224

Common marsh plant species of the Gulf Coast area. Volume I: Productivity. J. G. Gosselink, C. S. Hopkinson, Jr., R. T. Parrondo. Baton Rouge, LA, Louisiana State University, December 1977. Technical Report D-77-44 (NTIS No. AD-A052 094).

The results of a study of the net annual aerial primary productivity of seven marsh plants common to the Louisiana coastal marshes are presented. The Wiegert-Evans harvest technique was used to measure productivity over a 2-year period. Phenometric and gasometric techniques also were evaluated. Productivity was found to be related to the growth habit and turnover rate. *Spartina patens*, *Juncus roemerianus*, and *Distichlis spicata* were found to be more productive than *Spartina alterniflora*, a species that was known to be highly productive. Productivity was higher in the fresh and brackish marsh species than in the salt marsh species and was higher for species that grow throughout the winter than for those that die to the ground in late fall. The study showed that peak standing crop seriously underestimates production in Gulf Coast marshes and that the Wiegert-Evans harvest technique is the most realistic method presently available. This technique includes an estimate of mortality in addition to live biomass changes and so gives the closest estimate of true net aboveground production. The study also showed that phenometric methods have potential to be developed as reliable, nondestructive, estimating techniques. Appendices to the report discuss: (1) the determination of the productivity of the seven plant species using harvest techniques; (2) production of six species as determined by phenometric analysis; and (3) productivity of a *Spartina* marsh community as determined by gasometric analysis. 20 references. (Author abstract modified) Volume II is abstracted below.

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Common marsh plant species of the Gulf Coast area. Volume II: Growth dynamics. J. G. Gosselink, C. S. Hopkinson, Jr., R. T. Parrondo. Baton Rouge, LA, Louisiana State University, December 1977. Technical Report D-77-44 (NTIS No. AD-A052 095).

The growth dynamics of common Gulf Coast salt marsh species under conditions of stress are examined. Special emphasis is placed on the substrate selective qualities and adaptation mechanism of *Spartina alterniflora*. Techniques used in the investigation include: field studies, mineral analyses, greenhouse and laboratory studies, and *in situ* studies of photosynthesis. The large variations in growth of *S. Alternifora* are discussed in terms of: (1) geography as related to edaphic parameters; (2) salinity and flooding; and (3) the role of light and temperature in marsh plant photosynthesis. Findings are compared with other research reports concerning *S. alterniflora*. The results are integrated into a general conceptual model which has application to the development of marshes on dredged material. A general model is formulated in terms of three key growth parameters and two control loops which normally stabilize a marsh and determine its success. The critical parameters are salinity, limiting nutrients, and the degree of chemical reduction (Eh) of the soil. The two control loops, which interact through marsh vegetation growth, can be called the marsh elevation loop and the sediment Eh loop. A conceptual scheme of these relationships is provided. Appendices discuss: (1) spatial variation in peak biomass; (2) soil and tissue nutrients; (3) influence of iron source and concentration; (4) tissue and mineral analysis; (5) salinity and sediment drainage effects; (6) effect of salinity on rate of rubidium absorption; and (7) light and temperature responses. 25 references.

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Modeling of ecological succession and production in estuarine marshes. Joseph C. Zieman, William E. Odum Charlottesville, VA, University of Virginia, Department of Environmental Sciences, November 1977. Technical Report D-77-35 (NTIS No. AD-A051 929).

The results of an investigation of factors influencing plant zonation and succession on salt marshes are presented. Three parallel studies were conducted, with the development of a simulation model of plant growth and succession on a salt marsh being the ultimate objective. The first component was concerned with determining the biotic and chemical parameters present at a series of marshes. The second component involved obtaining continuous records of several physical and chemical parameters within several vegetation zones. The third component was the development of the simulation model. Appendices to this report contain: (1) the continuous monitoring system employed; (2) model user information, and (3) a list of survey sites. 79 references. For a separate section of the report, see the following abstract.

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Marsh succession model. In: *Modeling of ecological succession and production in estuarine marshes,* pp. 113-151. November 1977. Technical Report D-77-35.

A simulation model of plant growth and succession on salt marshes is described. The model was created by identifying the biotic and physical factors which control plant growth and by measuring these factors under field conditions. It was driven by solar radiation, temperature, soil salinity, and tidal inundation. It shows plant growth to be controlled mainly by tidal inundation, with influences felt from radiation and temperature but little influence felt from salinity. The model appears to hold great promise for future use but is presently limited in its application by incomplete parameterizations. For an overall summary of Technical Report D-77-35, see abstract no. 226.

228

State-of-the-art survey and evaluation of marsh plant establishment techniques: Induced and natural. Volume I: Report of research. John A. Kadlec, W. Alan Wentz. Ann Arbor, MI, University of Michigan, School of Natural Resources, December 1974. Contract Report D-74-9 (NTIS No. AD-A012 837).

The available information on the establishment of marsh and aquatic plants on sites created by dredging activity is reviewed. Geographic range, physicochemical habitat, salinity tolerance, and life form are discussed for a broad range of species. Ecotypic and ecophenic variation and modes of natural propagation are discussed for selected species. Aspects of propagation by man, including collection, storage, shipping, and planting of propagules, are presented. Key wildlife food plants are identified from the literature. Appendices contain: (1) names of serial publications reviewed, (2) a list of correspondents, and (3) selected references on naturalized and introduced aquatic and marsh angiosperms in North America. 418 references. Volume II is abstracted below.

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State-of-the-art survey and evaluation of marsh plant establishment techniques: Induced and natural. Volume II: A selected annotated bibliography on aquatic and marsh plants and their management. W. Alan Wentz, Rachel L. Smith, John A. Kadlec. Ann Arbor, MI, University of Michigan, School of Natural Resources, December 1974. Contract Report D-74-9 (NTIS No. AD-A012 837).

An annotated bibliography on aquatic and marsh plants and their management is provided. The volume concentrates on coastal, Great Lakes, and riverine marshes. 703 references.

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Guidelines for material placement in marsh creation. Final report. Lynn E. Johnson, William V. McGuinness, Jr. Hartford, CT, The Center for the Environment & Man, Inc., April 1975. Contract Report D-75-2 (NTIS No. AD-010 725).

A set of seven procedural guidelines is presented for creating new marshes from dredged material under a variety of situations and constraints. The guidelines are as follows: (1) determine if marsh creation warrants significant consideration, (2) define the dredging situation and determine the most likely types of marshes, (3) make preliminary comparison with other disposal alternatives, (4) refine basic properties, (5) focus on special characteristics, (6) recommend the best disposal alternative, and (7) design and construct the new marsh. New marshes are classified based upon dredging frequency, confinement requirements, and surcharging requirements. The report presents the important aspects of the physical environment, dredging operations, and engineering properties of dredged material as related to marsh creation, then incorporates these aspects into the guidelines. Appendices to the report contain: (1) site visit summaries; (2) weight and volume balance relations used in dredging; (3) a probability analysis of the likelihood of each type of marsh analysis; (4) examples of guideline applications; and (5) examples of containment area layout, construction, incremental fill placement, and drainage. 85 references.

231

Identification of relevant criteria and survey of potential application sites for artificial habitat creation. Volume I: Relevant criteria for marsh-island site selection and their application. Wilmington, NC, Coastal Zone Resources Corp., October 1976. Contract Report D-76-2 (NTIS No. AD-A033 525).

In the first volume of a report which develops a process for the selection of areas appropriate for marsh construction using dredged material, the biophysical and socioeconomic information needed to evaluate potential marsh creation sites is described, and the rationale underlying the emphasis on these data is presented. A two-scaled approach to analyzing the information base typically available to the Engineer District is detailed. The first, a reconnassance-scale evaluation combines intuitive judgment and available data. A more rigorous application of criteria is presented for the second, detailed-scale evaluation. Specific kinds of potential problems and theoretical approaches to their solution are also discussed. 130 references. (Author abstract)

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Identification of relevant criteria and survey of potential application sites for artificial habitat creation. Volume II: Survey of potential application situations and selection and description of optimum project areas. Wilmington, NC, Coastal Zone Resources Corp., October 1976. Contract Report D-76-2 (NTIS No. AD-A033 525).

In the second volume of a report which develops a process for the selection of areas appropriate for artificial marsh construction using dredged material, the selection rationale presented in Volume I is tested by the choice and description of 50 prime candidate project areas, 10 within each of five major coastal geographic regions. From this compilation, 10 optimum project areas, two in each geographic region, are selected and described further using data gathered in the project areas and from relevant Engineer Districts. The Appendix presents the form letter used in the mail survey. 94 references. (Author abstract)

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Design concepts for in-water containment structures for marsh habitat development. James W. Eckert, Michael L. Giles, Gerald M. Smith. Fort Belvoir, VA, U.S. Army Coastal Engineering Research Center, July 1978. Technical Report D-78-31 (NTIS No. AD-A058 732).

General guidance for structure selection and development of structure design and construction concepts for use in habitat development is provided. Various types of structures are reviewed based on the available literature. Steps to be followed in selecting an in-water confined disposal structure are enumerated, and case histories of structures in use are presented. An accompanying table lists known projects, their location, and their structural type. Structure selection problems also are examined. Appendices to this report contain (1) cost data and (2) structure data sheets. 27 references. (Author abstract modified)

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Recent and planned marsh establishment work throughout the contiguous United States--a survey and basic guidelines. E. W. Garbisch, Jr. St. Michaels, MD, Environmental Concern, Inc., April 1977. Contract Report D-77-3 (NTIS No. AD-A041 464).

Practical guidelines for marsh site preparation, marsh establishment, and site management and maintenance, developed on the basis of information received on deliberate marsh establishment work planned, underway, or completed throughout the contiguous United States within the period 1970-1976, are discussed. Surface slopes and surface elevations are discussed as the two most important factors found for preparing a site for marsh establishment. Within the tidal zone, surface slopes should be developed so that they exhibit reasonable stabilities in the absence of vegetative cover. Surface elevations must be carefully considered in the design and planning of a project and tied in with the various zones of marsh types existing in the region. Considerations and actions to be included in marsh establishment at a given site are listed, and marshscape architecture, maintenance, and management are discussed. All aspects of marsh establishment must be an integral part of the design and planning of the total project. Information was identified through a literature review, interviews, and by distributing information request forms. Appendices to the report contain (1) the list of correspondents and (2) the marsh creation research information request. 44 references.

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Establishment and growth of selected freshwater and coastal marsh plants in relation to characteristics of dredged sediments. Final report. John W. Barko, Richard M. Smart, Charles R. Lee, Mary C. Landin, Thomas C. Sturgis, Robert N. Gordon. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Effects Laboratory, March 1977. Technical Report D-77-2 (NTIS No. AD-A039 495).

The success of establishment and the growth of marsh plants on physically and chemically different dredged sediments were investigated under semicontrolled conditions in a greenhouse. Freshwater, brackish, and salt marsh environments were simulated for concurrent experimentation with various propagules of different species. Growth of individual marsh plant species was determined on the basis of stem density and total plant biomass. Growth of freshwater plants, affected by the availability of nitrogen, was significantly greater on fine-textured sediments than on sand. Growth of both brackish and salt marsh plants was relatively unrelated to nutrient availability and was affected most by the salinity of the sediment solution. Within the same period of growth, transplants produced plant populations having greater biomass and number of stems than did any of the other plant propagules. Rhizomes, rootstocks, and tubers responded similarly, but to a lesser extent, to sediment differences than transplant propagules of the same species. Recommendations relevant to marsh creation projects are made on the basis of results of this investigation as well as a review of the pertinent literature. 36 references and bibliographic entries. (Author abstract)

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Pregermination requirements and establishment techniques for salt marsh plants. Pat K. Falco, Frank J. Cali. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Effects Laboratory, September 1977. Miscellaneous Paper D-77-1 (NTIS No. AD-A045 514).

A state of the art review of data pertinent to pregermination requirements of salt marsh plant seeds and the procedures used for marsh establishment up to April 1974 is presented. Physiological and edaphic data have been included in an

attempt to enhance an objective choice of specific plants to be established under specific environmental conditions. Biological, operational, and engineering problems associated with marsh establishment are discussed. The Appendix presents a list of the scientific and common names of species used in this study. 32 references. (Author abstract modified)

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Influence of pregermination conditions on the viability of selected marsh plants. J. D. Maguire, G. A. Heuterman. Pullman, WA, Washington State University, Seed Technology Laboratory, August 1978. Technical Report D-78-51 (NTIS No. AD-A059 629).

A brief state-of-the-art review and laboratory tests were carried out to determine the viability and germination requirements of seed from 13 common freshwater and salt marsh plant species and to determine proper methods of seed storage and handling techniques to maximize viability. Selected species which exhibited considerable dormancy also were subjected to various gas and hormone treatments in an effort to break seed dormancy. The 13 species examined included sea ox-eye (*Borrichia frutescens*), Lyngby's sedge (*Carex lyngbyei*), slough sedge (*Carex obnupta*), tufted hairgrass (*Deschampsia caespitosa*), marsh elder (*Iva frutescens*), soft rush (*Juncus effusus*), broadleaf arrowhead (*Sagittaria latifolia*), woody glasswort (*Salicornia pacifica*), tule (*Scirpus validus*), smooth cordgrass (*Spartina alterniflora*), big cordgrass (*Spartina cynosuroides*), Pacific cordgrass (*Spartina foliosa*), and saltmeadow cordgrass (*Spartina patens*). Maximum percent germination for all species tested was 94 percent for slough sedge, lowest maximum germination rate was 15 percent for saltmeadow cordgrass (this has been tested higher in other situations). The study results provide useful and specific information about seed viability, dormancy, storage potential, and potential germination rates for the 13 marsh plant species tested. A list of common and scientific names used in the text of this report is appended. 58 references. (Author abstract modified)

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Feasibility study for Dyke Marsh Demonstration Area, Potomac River, Virginia. Michael R. Palermo, Timothy W. Ziegler. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Effects Laboratory, November 1976. Technical Report D-76-6 (NTIS No. AD-A033 524).

The results of an investigation conducted to determine the engineering feasibility of using dredged material from the Potomac River estuary to develop and restore a marsh community at Dyke Marsh, a freshwater intertidal marsh located south of Alexandria, Virginia, are presented. Factors evaluated in the study include (1) site-specific feasibility of marsh expansion using the locally available dredged material, (2) sizing of the demonstration area to meet water quality and storage needs, (3) location of the restoration project to conform with the desired plan of marshland development at Dyke Marsh; (4) preliminary design of the confined disposal facility; (5) availability of construction materials; (6) identification and investigation of possible construction alternatives; (7) procedures for placement of dredged material to produce the desired marsh substrate elevations; and (8) costs for different construction alternatives. The restoration of Dyke Marsh using dredged material appears technically feasible. This study represents an important contribution to the identification of the engineering constraints associated with a major marsh development site and provides basic design guidance which should be applicable to many estuarine areas. Appendices give laboratory test results for sediment samples and foundation soils. A subsequent detailed design for Dyke Marsh is presented in Technical Report D-77-13. 24 references.

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Detailed design for Dyke Marsh Demonstration Area, Potomac River, Virginia. Michael R. Palermo, Timothy W. Ziegler. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Effects Laboratory, October 1977. Technical Report D-77-13 (NTIS No. AD-A048 179).

Results are presented of detailed engineering studies on the use of dredged material to expand part of Dyke Marsh, a freshwater intertidal marsh about 1 mile south of Alexandria, Virginia, along the west bank of the Potomac River. Sampling and testing programs are described, and a methodology for correlation of in situ channel sediment volume and confined disposal area volume is given. Results of retaining dike stability analyses, dike settlement analyses, and erosion protection requirements are included. Appendices to the report give laboratory test results for (1) shoal and column sedimentation samples, (2) riverine sources of sand, (3) debris fill area and wooded island, and (4) foundation soils. 14 references. The feasibility study identifying the economic and technical constraints associated with dike construction and dredged material placement for marsh restoration at Dyke Marsh is described in Technical Report D-76-6.

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Habitat development field investigations, Windmill Point Marsh Development Site, James River, Virginia. Summary report. John D. Lunz, Timothy W. Ziegler, Robert T. Huffman, Robert J. Diaz, Ellis J. Clairain, Jr., L. Jean Hunt. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, August 1978. Technical Report D-77-23 (NTIS No. AD-A066 224).

Field research in habitat development at the Windmill Point Marsh Development Site, James River, Virginia, is presented. The research was designed to test the feasibility of using fine textured contaminated dredged material to establish freshwater marsh, mudflat, shallow aquatic, and upland habitats. Studies of engineering and construction operations, botany, sediment and water quality, metals and chlorinated hydrocarbon compounds in marsh soils and vascular plant tissues

benthic invertebrates, fish, and wildlife were included. 33 references. Appendices to this report represent the following individual studies which provide the data base upon which this Summary Report was developed: Appendix A: Assessment of vegetation on existing dredged material island, by G. M. Silberhorn and T. A. Bernard, Jr., Old Dominion University, Norfolk, Virginia (reproduced on microfiche and enclosed in the Summary Report); Appendix B: Propagation of vascular plants, by E. W. Garbisch, Jr., Environmental Concern, Inc., St. Michaels, Maryland (reproduced on microfiche and enclosed in the Summary Report); Appendix C: Environmental impacts of marsh development with dredged material: acute impacts on the macrobenthic community, by R. J. Diaz and D. F. Boesch, Virginia Institute of Marine Science, Gloucester Point, Virginia (printed report); Appendix D: Environmental impacts of marsh development with dredged material: botany, soils, aquatic biology, and wildlife, by Virginia Institute of Marine Science, Gloucester Point, Virginia (printed report); Appendix E: Environmental impacts of marsh development with dredged material: metals and chlorinated hydrocarbon compounds in marsh soils and vascular plant tissues, by J. D. Lunz, Environmental Laboratory, WES (printed report); Appendix F: Environmental impacts of marsh development with dredged material: sediment and water quality. Volume I: Characteristics of channel sediments before dredging and effluent quality during and shortly after marsh habitat development. Volume II: Substrate and chemical flux characteristics of a dredged material marsh, by D. D. Adams, D. A. Darby, and R. J. Young, Wright State University, Dayton, Ohio, and Old Dominion University, Norfolk, Virginia (printed report). *Appendices C, D, E, and F are abstracted below.*

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Habitat development field investigations, Windmill Point Marsh Development Site, James River, Virginia. Appendix C: Environmental impacts of marsh development with dredged material: acute impacts on the macrobenthic community. Robert J. Diaz, Donald F. Boesch. Gloucester, VA, Virginia Institute of Marine Science, November 1977. Technical Report D-77-23 (NTIS No. AD-A066 224).

Tidal freshwater macrobenthos was sampled near the Windmill Point, Virginia dredged material island site. Benthic communities were dominated by the bivalve *Corbicula manilensis*, oligochaetes *Limnodrilus* spp., *Ilyodrilus templetoni*, *Limnodrilus hoffmeisteri*, and larva of insects *Coelotanypus scapularis* and *Hexagenia mingo*. Densities were greatest in mud substrates with the exception of *Corbicula manilensis*. The community had recovered from the sedimentation impacts of island construction and dredging within six months.

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Habitat development field investigations, Windmill Point Marsh Development Site, James River, Virginia. Appendix D: Environmental impacts of marsh development with dredged material: botany, soils, aquatic biology, and wildlife. Donald F. Boesch, Robert J. Diaz, D. Doumlele, J. L. Hauer, M. Hedgepeth, J. V. Merriner, K. Munson, S. Powers, G. Silberhorn, C. A. Stone, M. Wass, R. Wetzel, E. Wilkins. Gloucester, VA, Virginia Institute of Marine Science, June 1978. Technical Report D-77-23 (NTIS No. AD-A066 223).

A 4.0-ha intertidal marsh island was built from dredged material in the James River; benthic invertebrates, fish, wildlife, plants, and soils chaacteristics were studied. The man-made island was found to have increased species abundance, diversity, and biomass over adjacent open-water areas; it was found to have greater abundance and biomass of a less diverse benthos, fish, and wildlife community than nearby natural marshes. The developed marsh habitat was beneficial and compared favorably with natural reference areas in terms of fish and wildlife resources and productivity.

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Habitat development field investigations, Windmill Point Marsh Development Site, James River, Virginia. Appendix E: Environmental impacts of marsh development and chlorinated hydrocabon compounds in marsh soils and vascular plant tissues. John D. Lunz. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, August 1978. Technical Report D-77-23 (NTIS No. AD-A066 224).

Soil and vascular plant tissue samples were collected from the man-made Windmill Point Marsh Development Site and two nearby natural marshes and analyzed for five heavy metals (nickel, zinc, chromium, lead, and cadmium) and thirteen chlorinated hydrocarbon compounds (DDT, DDD, DDE, lindane, heptachlor, heptachlor epoxide, chlordane, endrine, dieldrin, kelthane, kepone, PCB's, and toxaphene). No real differences between levels in the man-made and natural marshes was evident in plant tissues although soil concentrations were higher for some metals and chlorinated hydrocarbons in the man-made marsh soil. Kepone was detected in all marsh soils studied. Marsh soil characteristics appear to restrict chemical mobility and bioavailability and to degrade chlorinated hydrocarbons.

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Habitat development field investigations, Windmill Point Marsh Development Site, James River, Virginia. Appendix F: Environmental impacts of marsh development with dredged material: sediment and water quality. Volume I: Characteristics of channel sediments before dredging and effluent quality during and shortly after marsh habitat development. Volume II: Substrate and chemical flux characteristics of a dredged material marsh. [1]Donald D. Adams, [2]Dennis A. Darby, [2]Randolf J. Young. [1]Dayton, OH, Wright State University; [2]Norfolk, VA, Old Dominion University, August 1978. Technical Report D-77-23 (NTIS No. AD-A066 224).

Volume I: Navigation channel sediments were collected before dredging and physically and chemically described. These characteristics were compared to the chemical quality of effluent from the site during dredging, during dewatering, and 3.5 months after dredging and disposal. Concentrations in the effluent leaving the dike from the disturbed sediments during dredging were higher for zinc, copper, cadmium, lead, nickel, mercury, and ammonium-N. Lower concentrations of dissolved iron and orthophosphate were found. The high concentrations decreased substantially by 3.5 months after dredging. Volume II: Substrate sediment studies were conducted at the marsh development site and at a natural reference marsh 6, 18, and 24 months after dredging and disposal. Thirteen variables were found to be different between the man-made and natural reference marsh. Eight were higher at the man-made site: conductivity, total phosphorus, turbidity, orthophosphate, nitrate plus nitrite, calcium, manganese, and volatile organic carbon. Two were higher at the reference marsh: pH and dissolved oxygen. Export and import properties of both marshes were studied and transport calculations made for a number of substances.

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Habitat development field investigations, Buttermilk Sound Marsh Development Site, Atlantic Intracoastal Waterway, Georgia. Summary report. Richard A. Cole. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, July 1978 Technical Report D-78-26 (NTIS No. AD-A057 937).

The activities that occurred during marsh development studies at Buttermilk Sound, Glynn County, Georgia between 1975 and 1977 are summarized. A general discussion of the engineering and biological aspects of salt marsh propagation, microbial development, and associated animal response is presented. Among the factors tested for their effect on marsh development on dredged material, elevation and the associated amount of inundation had the greatest impact. Fertilization did not appear to facilitate plant survival or performance even though the dredged material had low nutrient concentrations. At Buttermilk Sound, seeding was just as effective as sprigging for all of the species planted. Construction of the experimental site and the planting that followed seemed not to have any major effect on aquatic or terrestrial animals. 9 references. (Author abstract modified) Detailed information on propagation of plants and postpropagation monitoring is appended to this report. That appendix provided much of the data base for the Summary Report. Appendix A: Propagation of marsh plants and postpropagation monitoring, by R. J. Reimold, M. C. Hardisky, and P. C. Adams, University of Georgia, Brunswick, Georgia (printed report). Appendix A is abstracted below.

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Habitat development field investigations, Buttermilk Sound Marsh Development Site, Atlantic Intracoastal Waterway, Georgia. Appendix A: Propagation of marsh plants and postpropagation monitoring. R. J. Reimold, M. C. Hardisky, P. C. Adams. Brunswick, GA, University of Georgia, July 1978. Technical Report D-78-26 (NTIS No. AD-A057 937).

A field study testing the feasibility and impact of marsh development using dredged material at Buttermilk Sound, Georgia, was initiated in 1975. A 2-ha dredged material island near the Altamaha River mouth was graded to a 3.7 percent slope and partitioned into three elevation zones which were subjected to tidal inundation less than six hours each day, six to 18 hours each day, and more than 18 hours each day, respectively. Each zone was treated with a combination of experimental plantings including seven marsh plant species, two propagule types, and five fertilizer treatments. Species tested were *Spartina alterniflora, Spartina patens, Spartina cynosuroides, Borrichia frutescens, Iva frutescens, Juncus roemerianus,* and *Distichlis spicata*. Plant response to fertilizer and inundation was monitored. Interstitial water chemistry, soil chemistry, soil microbiology, and invading plant species were monitored within each plot. Aquatic biota and wildlife observations were also made.

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Habitat development field investigations, Apalachicola Bay Marsh Development Site, Apalachicola Bay, Florida. Summary report. [1]William L. Kruczynski, [2]Robert T. Huffman, [2]Mary K. Vincent. [1]Tallahassee, FL, Environmental Systems Service of Tallahassee, Inc.; [2]Vicksburg, MS, U.S. Army Engineers Waterways Experiment Station, Environmental Laboratory, August 1978. Technical Report D-78-32 (NTIS No. AD-A059 722).

The feasibility of developing marsh on fine-grained and coarse-grained dredged material in a brackish water intertidal environment was tested at a dredged material disposal site in Apalachicola Bay, Florida. Smooth cordgrass (*Spartina alterniflora*) and saltmeadow cordgrass (*Spartina patens*) sprigs were planted at different spacing intervals to evaluate optimum growth conditions. Fourteen months after planting, plots of saltmeadow cordgrass and smooth cordgrass exhibited substantial growth. In the smooth cordgrass spacing study, growth measures were related to plant interval, and, in general, growth improved as spacing decreased. In contrast,

general growth within the saltmeadow cordgrass plots improved as planting interval increased. Natural invasion of plant species also was documented. Reliance solely upon natural invasion to initially stabilize dredged material sites with environmental conditions similar to the ones described in this report is not recommended, because the development of sufficient ground cover is often happenstance. Results indicate that the development of marsh plants on dredged material can be readily accomplished in the area of study. 8 references. (Author abstract modified)

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Habitat development field investigations, Bolivar Peninsula Marsh and Upland Habitat Development Site, Galveston Bay, Texas. Summary report. Hollis H. Allen, Ellis J. Clairain, Jr., Robert J. Diaz, Alfred W. Ford, L. Jean Hunt, B. R. Wells. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, August 1978. Technical Report D-78-15 (NTIS No. AD-A063 780).

A 2.5-year field investigation was conducted at Bolivar Peninsula, Galveston Bay, Texas, to test the feasibility and impact of developing marsh and upland habitats on dredged material. This report summarizes baseline information derived before habitat development operations and the results of postdevelopment operations. Two marsh grass species and nine upland plant species including trees, shrubs, and grasses were planted in test plots on a dredged material site lying between the Gulf Intracostal Waterway and Galveston Bay. Tests were conducted to measure plant survival and performance in response to different fertilizer treatments and planting methods. Plantings were successful in both marsh and upland. Marsh grasses surviving and performing well included smooth cordgrass (*Spartina alterniflora*) and saltmeadow cordgrass (*Spartina patens*). Upland plants demonstrating good survival and growth were live oak (*Quercus virginiana*), wax myrtle (*Myrica cerifera*), winged sumac (*Rhus copallina*), bitter panicum grass (*Panicum amarum*), and coastal bermuda grass (*Cynodon dactylon* var *alecia*). Components of the habitat development site, consisting of the planted vegetation and sandbag dike, attracted insects, acquatic organisms, and birds. After less than a year of development, the site provided heterogeneous habitats which tended to support greater use by fish and benthos than is generally associated with sandy shores along the Bolivar Peninsula. Appendices to this report represent the following individual studies which provide the data base upon which this Summary Report was developed. Appendix A. Baseline inventory of water quality, sediment quality, and hydrodynamics, by J. D. Lunz, E. J. Clairain, Jr., and J. W. Simmers, Environmental Laboratory, U.S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Mississippi (reproduced on microfiche and enclosed in the Summary Report). Appendix B. Baseline inventory of terrestrial flora, fauna, and sediment chemistry, by J. D. Dodd, D. J. Herlocker, B. W. Cain, B. J. Lee, L. R. Hossner, and C. Lindau, Texas A&M University, College Station, Texas (reproduced on microfiche and enclosed in the Summary Report). Appendix C. Baseline inventory of aquatic biota, by J. M. Lyon and K. N. Baxter, National Marine Fisheries Service, Galveston, Texas (reproduced on microfiche and enclosed in the Summary Report). Appendix D. Propagation of vascular plants and postpropagation monitoring of botanical, soil, aquatic biota, and wildlife resources, by J. W. Webb, J. D. Dodd, B. W. Cain, W. R. Leavens, L. R. Hossner, C. Lindau, R. R. Stickey, and H. Williamson, Texas A&M University, College Station, Texas (printed report). Appendix D is abstracted below.

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Habitat development field investigations, Bolivar Peninsula Marsh and Upland Habitat Development Site, Galveston Bay, Texas. Appendix D: Propagation of vascular plants and postpropagation monitoring of botanical, soil, aquatic biota, and wildlife resources. J. W. Webb, J. D. Dodd, B. W. Cain, W. R. Leavens, L. R. Hossner, C. Lindau, R. R. Stickney, H. Williamson. College Station, TX, Texas A&M University, June 1978. Technical Report D-78-15 (NTIS No. AD-A063 780).

Post development monitoring activities are summarized. Plant survival and performance in response to different fertilizer treatments and planting methods were measured. Soil parameters were analyzed and related to plant growth. Aquatic biota was monitored for invasion and composition. Wildlife observations were made to determine reptile, amphibian, mammal, and bird use of the site.

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Habitat development field investigations, Salt Pond No. 3 Marsh Development Site, South San Francisco Bay, California. Summary report. [1]James H. Morris, [1]Curtis L. Newcombe, [2]Robert T. Huffman, [2]James S. Wilson. [1]Richmond, CA, San Francisco Bay Marine Research Center, Inc. [2]Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, December 1978. Technical Report D-78-57 (NTIS No. AD A065 775).

A marsh demonstration study involving the development of a salt marsh habitat on unconfined fine-grained dredged material deposited along the banks of the Alameda Creek Flood Control Channel in South San Francisco Bay is discussed. Testing of this concept in 1972 demonstrated its feasibility, and in 1974 a 40.4-ha *confined (diked) saltwater evaporation* pond (Salt Pond No. 3) was filled with approximately 500,000 m^3 of fine-grained clayey dredged material as part of field work aimed at providing information on the development of a cordgrass (*Spartina foliosa*) marsh on confined dredged material substrate. The project was concerned with: (1) the maximum distance to space propagules and obtain satisfactory cover in two years, (2) the possible need for substrate preparation prior to planting, (3) the suitable elevation range for planting, (4) the optimal season for planting, and (5) the efficiency of hand planting by the walk method as compared with hand planting by the tractor assisted method. Natural colonization by plant species on the site also was documented. 3 references.

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Habitat development field investigations, Miller Sands Marsh and Upland Habitat Development Site, Columbia River, Oregon. Summary Report. Ellis J. Clairain, Jr., Richard A. Cole, Robert J. Diaz, Alfred W. Ford, Robert T. Huffman, L. Jean Hunt, B. R. Wells. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, November 1978. Technical Report D-77-38.

A two and one-half year field investigation conducted at Miller Sands Island, a tidal freshwater, dredged material disposal site in the Columbia River, Oregon, is summarized. The field study was conducted to determine the feasibility of developing productive marsh and terrestrial wildlife habitat on dredged material and to determine if development of wildlife habitat is a viable alternative to other dredged material disposal options. This report synthesizes baseline information obtained before habitat development operations and the results of postdevelopment operational studies. Plantings were generally successful in both the intertidal and upland areas. The intertidal plantings provided habitat for aquatic and terrestrial animal communities but did not greatly improve or damage animal populations. The planted upland areas were used by waterfowl more than upland reference areas, although the number of avian species was less. 28 references. (Author abstract modified) Appendices to the report present the following individual studies which provided the data base upon which this Summary Report was developed: Appendix A: Inventory and assessment of predisposal physical and chemical conditions, by N. Cutshall and V. G. Johnson, Oregon State University, Corvallis, Oregon (reproduced on microfiche and enclosed in the Summary Report), Appendix B: Inventory and assessment of predisposal and postdisposal aquatic habitats by R. J. McConnell, et al., National Marine Fisheries Service, Seattle, Washington (reproduced on microfiche and enclosed in the Summary Report), Appendix C: Inventory and assessment of prepropagation terrestrial resources on dredged material, by C. D. White, et al., Woodward-Clyde Consultants, Portland, Oregon (reproduced on microfiche and enclosed in the Summary Report), Appendix D: Propagation of vascular plants on dredged material, by W. E. Ternyik, Wave Beach Grass Nursery, Florence, Oregon (reproduced on microfiche and enclosed in the Summary Report), Appendix E: Postpropagation assessment of botanical and soil resources on dredged material, by P. E. Heilman, et al., Washington State University, Pullman, Washington (printed report), and Appendix F: Postpropagation assessment of wildlife resources on dredged material, by J. A. Crawford and D. K. Edwards, Oregon State University, Corvallis, Oregon (printed report). Appendices E and F are abstracted below.

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Habitat development field investigations, Miller Sands Marsh and Upland Habitat Development Site, Columbia River, Oregon. Appendix E: Postpropagation assessment of botanical and soil resources on dredged material. P. E. Heilman, D. M. Greer, S. E. Brauen, A. S. Baker. Pullman, WA, Washington State University, August 1978. Technical Report D-77-38 (NTIS No. AD-A062 261)

Development of soil characteristics and planted marsh and upland vegetation were examined at Miller Sands Island, a dredged material disposal site in the Columbia River, Oregon. Soil analyses showed uniform soil conditions with sandy textures. The soil was also very low in organic matter and nitrogen but had relatively high base status and pH. The phosphorus level was higher than levels found in adjacent natural soils. Although marsh soils were somewhat less oxidized at lower elevations, the soil was relatively well aerated and contained no sulfides or nitrates. Plant growth survival in the marsh indicated significant effects of elevation with almost no plants surviving in the lowest elevations planted. Aerial biomass production in the planted marsh was over five times greater than in the unplanted beach area, but about one-third as great as the natural marsh area. Fertilization significantly increased growth, seed production, and biomass of *Deschampsia cespitosa*, but had no effect on *Carex obnupta*. Good plant growth was obtained with most species planted on the upland area. Fertilization was necessary for the establishment of most upland species even though competition from invading grasses greatly increased with application of fertilizer. Barley, red clover, white clover, and bentgrass produced flowers after the first year of growth, but seed production was poor.

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Habitat development field investigations, Miller Sands Marsh and Upland Habitat Development Site, Columbia River, Oregon. Appendix F: Postpropagation assessment of wildlife resources on dredged material. J. A. Crawford, D. K. Edwards. Corvallis, OR, Oregon State University, May 1978. Technical Report D-77-38. (NTIS No. AD-A056 873)

Wildlife response to plant propagation on Miller Sands Island, a dredged material disposal site in the lower Columbia River, was assessed from July 1976 through August 1977. Plant establishment was accomplished in late summer and fall of 1976. Data on birds, mammals, and terrestrial macroinvertebrates were collected, analyzed, and compared with data from other regions of the United States. Six habitat types were examined: natural beach, marsh, upland, and tree-shrub, planted marsh, and planted upland. The planted marsh was used by fewer bird species than was a reference marsh; however, a trend developed near the end of the study which indicated that use of both will eventually be similar. Upland plantings apparently increased the diversity and number of species which used adjacent upland areas. Waterfowl fed and nested in the upland plantings, preferring a bar

ley/bentgrass/red clover mix for feeding and a reed canary grass/red fescue/hairy vetch mix for nesting. Very few small mammals were trapped, but it appeared that the Townsend's vole population increased in the upland canary grass/fescue/vetch mix. Macroinverterate populations increased on the upland. Plantings did not have dramatic effects on the animal populations monitored. Avian density and diversity were mostly unaffected. But in some instances, the number and type of species changed in response to the plantings.

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Habitat development field investigations, Rennie Island Marsh Development Site, Grays Harbor, Washington. Summary report. Mary K. Vincent. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Effects Laboratory, April 1978. Technical Report D-78-11 (NTIS No. AD-A056 909)

Activities occurring during the habitat development field study at Rennie Island in Grays Harbor at Aberdeen, WA are summarized. The objective of the study was to develop a salt marsh on a dredged material substrate. Early in the site assessment phase, however, the project was found to be infeasible due to extremely high wave energy conditions, necessitating a substantial protective and retaining structure. Foundation analyses indicated a weak, unstable condition that made a conventional rock or earthen dike unsuitable. An evaluation of various alternative structures revealed that no economically feasible options were available, and the project was terminated. Appendices include: (1) an annotated bibliography for Grays Harbor estuary; (2) a list of plants and animals observed in the study area, (3) the work plan for the Rennie Island study; and (4) a discussion of engineering considerations. 21 references. (Author abstract modified)

Island Habitat Development

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Use of dredged material islands by colonial seabirds and wading birds in New Jersey. Francine G. Buckley, Cheryl A. McCaffrey. Manomet, MA, Manomet Bird Observatory, June 1978. Technical Report D-78-1 (NTIS No. AD-A061 843)

Results of investigations of (a) the distribution of colonial seabirds and wading birds on New Jersey dredged material islands, (b) vegetation distribution and succession on dredged material islands, and (c) the interactions of vegetation and birds on dredged material islands are summarized. Vegetation field studies were conducted using photointerpretation, *on-site vegetation sampling, general field reconnaissance*, and calculation of areas covered by various vegetation mapping units. Sixteen colonial waterbird species were found nesting in the study area, all but one species were often associated with dredged material islands were of greatest importance to wading birds. The vegetation communities and seral stages found on 21 dredged material study islands are described. Nineteen recommendations for dredged material islands as a wildlife resource are stated, including annual wildlife surveys, careful monitoring of dredging contractor performance, attention to record keeping, preservation of alternative colony sites, rotational use and management of dredged material islands, proportional habitat creation and management, and protection of all islands with bird colonies. Appendices contain: (1) an historical perspective, (2) vegetation analysis; (3) miscellaneous maps and figures, and (4) photographs of the 21 study islands. 49 references.

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A comparison of plant succession and bird utilization on diked and undiked dredged material islands in North Carolina estuaries. James F. Parnell, David M. DuMond, Robert N. Needham. Wilmington, NC, University of North Carolina at Wilmington, Department of Biology, May 1978. Technical Report D-78-9 (NTIS No. AD-A056 000)

A comparative study of the vegetation succession and avian use of North Carolina's 395 diked and undiked dredged material islands is reported. Unfilled diked islands that were studied had a complex topographic zonation. Plant succession was highly variable on these unfilled sites, with topography, substrate particle size, salinity, and availability of water being major causative factors. Plant succession on diked and filled sites was similar to that on undiked islands except that dikes tended to vegetate more quickly than did the deposits on outer portions of undiked sites. Only the least and gull-billed terns were found nesting predominately on diked sites, with most nesting gulls and terns locating the majority of their breeding colonies on undiked sites. One hundred forty-two species of shorebirds, waterfowl, and land birds were recorded on diked islands, while 94 species were found on undiked sites, the increased avian diversity of diked over undiked sites paralleling the increased temporary diversity of habitats on diked sites. Although most conclusions and recommendations concerning diking and birds must be very tentative, there clearly are few positive values of dikes to nesting birds and several potential adverse effects. The findings of this study relate closely to diked sites on the mid Atlantic Coast and reasonably well to diked Gulf Coast sites. Appendices to this report contain soils, vegetation, bird, and cartographic data, respectively. 58 references. (Author abstract modified)

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Colonial bird use and plant succession on dredged material islands in Florida. Volume I: Sea and wading bird colonies. Ralph W. Schreiber, Elizabeth A. Schreiber. Culver City, CA, Seabird Research, Inc., April 1978. Technical Report D-78-14 (NTIS No. AD-A056 086)

Bird use of dredged material islands in five areas of Florida was studied, concentrating on colonial nesting habits of sea

and wading species. Breeding use, use during migration, and overwintering use were considered, and two surveys were made on each of 40 selected islands to identify the 26 species of colonial and 8 species of noncolonial birds. Various species-habitat interactions and the significance of dredged material islands to colonial nesting sea and wading birds are discussed in detail. Five management recommendations are made. Appendices to this report contain (1) a literature review and 1977 field data and (2) a discussion of bird use of dredged material islands as roosting, loafing, and feeding sites. 67 references. (Author abstract modified)

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Colonial bird use and plant succession on dredged material islands in Florida. Volume II: Patterns of plant succession. Roy R. Lewis, III, Carolyn S. Lewis. Culver City, CA, Seabird Research, Inc., April 1978. Technical Report D-78-14 (NTIS No. AD-A056 803).

The succession of vegetation on various aged dredged material islands in Florida was determined. Forty islands in five selected areas were examined intensively, and a literature review was conducted. Vertical aerial photographs and vegetation maps of each island were made. A total of 141 plant species were identified as occurring on the islands. Colonization by propagules occurred from water-carried, wind-carried, and bird-carried sources on Florida dredged material islands. Bird use of the islands was directly related to the stage of succession, and bird fecal material was found to affect the regetation both adversely and benefically depending upon location. The opportunities for bird usage offered by the creation of new dredged material islands, by the addition of dredged material to existing islands or by the maintenance of unregetated sites are discussed in terms of management guidelines. 36 references. (Author abstract modified)

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Use of dredged material islands by colonial seabirds and wading birds in Texas. A. H. Chaney, B. R. Chapman, J. P. Karges, D. A. Nelson, R. R. Schmidt, L. C. Thebeau. Kingsville, TX, Texas A&I University, April 1978. Technical Report D-78-8 (NTIS No. AD-A056 785).

Data were gathered on the use of dredged material islands by colonial seabirds and wading birds in 34 locations in Texas waters, 17 in the Galveston-Houston area and 17 in the upper Laguna Madre near Corpus Christi. The islands were photographed, visited by boat, and measured for elevation and area. Over 3000 soil samples were taken, and the vegetation on each island was identified, measured, and quantified in over 3000 quadrats. Plant communities were identified, and vegetation maps of each island were constructed. Birds using the islands as nesting sites were identified and their nests monitored. The location of colonies was plotted on island maps and nesting information was summarized and placed in tabular form. Islands, birds, and vegetation were related to each other, and the numbers and species of nesting birds were compared with those nesting on natural sites in each area and for the entire Texas coast. The report contains recommendations concerning island construction, maintenance, and management in relation to nesting seabirds and wading birds. Appendices present: (1) nesting sites on the Texas coast used by colonial and wading birds in 1976; (2) maps of the two study areas; (3) name, designation, location, and physical characteristics of islands in the specific study areas; (4) plant species collected from islands in the southern area; (5) plant species collected from islands in the northern area; (6) physical characteristics and occurrence of plant species in all quadrats on each study island; (7) bird species nesting on dredged material islands in the two study areas on the Texas coast during 1977; (8) nesting information on birds using dredged material islands along the coast of Texas; and (9) nesting information on colonial birds that nested on dredged material islands in the two study areas on the Texas coast during 1977. 116 references. (Author abstract modified)

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Colonial nesting sea and wading bird use of estuarine islands in the Pacific Northwest. Carl F. Peters, Klaus O. Richter, David A. Manuwal, Steven G. Herman. Seattle, WA, John Graham Company, May 1978. Technical Report D-78-17 (NTIS No. AD-A056 926).

Between June and September 1977, 23 natural and dredged material islands were examined in seven locations from Anacortes, Washington, to Coos Bay, Oregon, to establish the relationships between plant communities and use by colonial nesting waterbirds for both types of islands, as well as the actual bird use of dredged material islands in the Pacific Northwest. Nine islands were found to be used for nesting by several species including glaucous-winged gulls, western-glaucous-winged (hybrid) gulls, ring-billed gulls, Caspian terns, and common terns. Colonies of great blue herons were found on two islands 61 and 97 km from the mouth of the Columbia River. Colony location, breeding phenology, and nesting success were analyzed with respect to existing flora, environmental stress, island physiography, and human disturbance. Results show that although dredged material deposition influenced an island's physical dimensions, topography, and substrate, plant communities were physiognomically similar to natural islands, and seabird colonization occurred irrespective of dredging history. Colonization and productivity were related primarily to protection from environmental stress. Management of dredged material islands should not necessarily be directed toward increased gull and tern production, but existing colonies should be maintained and monitored, especially those of rare species on the West Coast (Caspian terns and common terns). Dredged material deposition could improve habitat on some islands by providing increased stability and protection from environmental stress. Appendices present: (1) island vegetation composition and relative density by habitat type and life form; (2) an index to plant species of Pacific Northwest estuarine islands; (3) an index to bird species; and (4) an index to mammal species. 36 references. (Author abstract modified)

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An aerial survey of waterbird colonies along the Upper Mississippi River and their relationship to dredged material deposits. David H. Thompson, Mary C. Landin. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Effects Laboratory, April 1978. Technical Report D-78-13 (NTIS No. AD-A056 059).

Aerial surveys of 1040 km of the Upper Mississippi River, Locks and Dams 1-26, showed 35 active colonies of five species of waterbirds (*great blue heron, great egret,* black-crowned night heron, double-crested cormorant, and Forster's tern) nesting in the floodplain. In addition, green herons and yellow-crowned night herons are reported as nesting, although location by aerial survey was not possible due to cryptic coloration and nest placement beneath the tree canopy. No species were found nesting on dredged material. In general, colonies were located on isolated insular natural sites on the east side of the river below dams and/or tributaries. Many dredged material sites were found to be unsuitable for nesting because of high human recreational use of dredged material and the early successional stage of vegetation present. Appendices name the bird and plant species listed in the text and give tabulations of data for active and extinct colonies. 96 references. (Author abstract)

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Colonial birds nesting on man-made and natural sites in the U.S. Great Lakes. William C. Scharf, Gary W. Shugart, Michael L. Chamberlin. Traverse City, MI, Northwestern Michigan College, May 1978. Technical Report D-78-10 (NTIS No. AD-A061 818)

Habitats and nesting populations of colonial nesting birds of the U.S. Great Lakes were determined by aerial census, ground nest observations, and vegetation analysis during 1976 and 1977. Thirteen species at 267 colonies were found during this 2-year study. An atlas of nesting sites and populations for both years is included along with results of intensive vegetation and habitat analyses of 24 sites, of which eight were natural islands and 16 were dredged material locations. Avian wildlife included several species of egrets, herons, gulls, and terns. Appendices to this report present (1) maps of the colonies studied, (2) a listing of common and scientific names of plants, (3) data on the relative density, coverage, and frequency of plants in the sample area, and summaries of the colonial nesting surveys in (4) the St. Marys River area and (5) the Beaver Islands archipelago. 35 references. (Author abstract modified)

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A selected bibliography of the life requirements of colonial nesting waterbirds and their relationship to dredged material islands. Mary C. Landin. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, September 1978. Miscellaneous Paper D-78-5 (NTIS No. AD-A061 643)

An extensive bibliography of pertinent research on the life requirements of colonial nesting waterbirds in the United States and their relationship to dredged material is presented. An additional bibliography of 181 references pertaining to the vegetation and soils on dredged material islands and environmental impacts of dredged material deposition on waterbird habitats also is provided. Selected references from Canada, Europe, and Africa which pertain to related waterbirds or to those introduced to the United States are included. This report gives the reader access to little known sources and presents data on waterbird species that are not otherwise readily available. References from the years 1844 to 1978 are included. 4 references. (Author abstract)

Terrestrial Habitat Development

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The flora of dredged material sites in Navigation Pool 8 of the Upper Mississippi River. S. R. Ziegler, S. H. Sohmer. La Crosse, WI, University of Wisconsin, La Crosse, November 1977. Technical Report D-77-31 (NTIS No. AD-A050 778)

Vegetation growing on dredged material in Navigation Pool 8 of the Upper Mississippi River was surveyed to determine plant species. Twenty-three sites ranging in age from one to over 20 years were studied, and specimens collected of 304 species representing 64 plant families. Site ages, elevations, and plant community associations were correlated to determine primary colonizers of the various dredged material habitats. Grasses, sedges, and composites were the primary herbaceous colonizers. 29 references.

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Annotated tables of vegetation growing on dredged material throughout the United States. Mary C. Landin. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, November 1978. Miscellaneous Paper D-78-7 (NTIS No. AD-A068 459)

Tabular data collected on the vegetation of dredged material islands and sites in Corps of Engineers maintained waterways throughout the United States are presented. More than 1,000 of the 2,000 dredged material islands and sites built in the past 100 years were surveyed aerially to determine wildlife

use, and 202 of these were sampled intensively and had all vegetation recorded, identified, and/or collected as voucher specimens. With the exception of the marsh plant species tables, the tables are presented by growth habit groups: ferns and their allies, grasses, aquatic and low marsh plants not included elsewhere, herbs, vines, shrubs and small trees, and large trees. Table 1 provides an annotated listing by common name for easy reference to 1,120 plant species occurring on dredged material; frequency and occurrence are briefly noted. Table 2 presents a selection of 361 upland and high marsh plant species that may be planted on dredged material for wildlife habitat enhancement and substrate stabilization. Table 3 gives a matrix of upland plants based on the same 361 species. Data include: best propagule types and propagule collection periods, temporary storage requirements, and planting periods, species range, heights, growth habits, wildlife value, salinity tolerances, and pertinent remarks on cultivation value, pest species, and habitat occupation, and species occurring on dredged material and their availability from commercial sources. Tables 4 and 5 present pertinent information beneficial to site planners of wetlands habitats, including: recommended propagules, planting and storage techniques, ranges, soil tolerances, moisture requirements, wildlife value, nuisance potential, soil stabilization abilities, and pertinent remarks on individual values and benefits to be derived from each species. A total of 115 species, selected for their ability to grow on wetlands sites, is listed. Table 6 gives an alphabetical, grouped listing by scientific name and authority of the 1,120 species occurring on dredged material. 48 references.

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A comprehensive study of successional patterns of plants and animals at upland disposal areas. Wilmington, NC, Coastal Zone Resources Corp., March 1977. Contract Report D-77-2 (NTIS No. AD-A040 464).

The existing biota and plant and animal successional patterns at five upland dredged material disposal areas in the United States are examined. The sites are: (a) Nott Island in the Connecticut River, (b) six islands in Hillsborough Bay near Tampa, Florida, (c) an area paralleling a portion of the Whiskey Bay Pilot Channel in the Atchafalaya River basin of Louisiana, (c) a a disposal area paralleling a short segment of the Gulf Intracoastal Waterway between Port Arthur and Galveston, Texas, and (e) Mott Island in the Columbia River near Astoria, Oregon. With the aid of historical aerial photography, on-site analysis, and regional biological information, successional patterns of each site are discussed. Annotated lists of plant and vertebrate animal species encountered during the study are included as appendices to the report. 148 references. (Author abstract modified)

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Review of dredged material disposal techniques to identify wildlife habitat development factors. San Francisco, CA, Dames & Moore, December 1977. Miscellaneous Paper D-77-5 (NTIS No. AD-A063 441).

Habitats of 15 inland confined dredged material disposal sites were studied, along with operative disposal techniques for dredged material. The objective was to determine wildlife enhancement alternatives which will protect existing wildlife habitat while not unduly conflicting with maintenance dredging techniques and equipment capabilities. It is emphasized that the smaller the confined disposal area, the more rapidly ecological succession of the disposal site will occur. Succession depends on the size of the site and on frequency and location of the deposition of the dredged material. Specific enhancement techniques and alternatives were developed for five of the 15 sites. Environmental and economic costs and benefits of proposed alternatives were categorized into long-term and short-term costs, and benefits and costs were compared. (Author abstract modified)

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Handbook for terrestrial wildlife habitat development on dredged material. Wilmington, NC, Ocean Data Systems, Inc., Coastal Zone Resources Division, July 1978. Technical Report D-78-37 (NTIS No. AD-A061 114).

The results of a study of terrestrial wildlife habitat development on dredged material within the contiguous United States are compiled in a user oriented handbook. A general list of 250 plant species (including trees, shrubs, vines, herbs, and grasses) with food and cover value for wildlife is indexed by life form and state; a synopsis is given for each of 100 plant species chosen from the general list on the basis of their importance to wildlife, ease of establishment, and geographic distribution. Each synopsis includes a description and discussion of habitat, soil requirements, establishment and maintenance, disease and insect problems, and wildlife value. A range map and illustration are given along with appropriate miscellaneous comments. The handbook also outlines a suggested approach for developing terrestrial wildlife habitat on dredged material, discusses wildlife species inhabiting dredged material areas, and recommends techniques for propagation, establishment, and maintenance of plantings. Appendices to this report contain: (1) the list of 250 plants with food or cover value for wildlife, indexed by state and life form; (2) rare, endangered, or threatened species references; and (3) addresses for soil conservation service plant materials specialists, plant materials centers, and regional biologists. 176 references. A list of 184 other, uncited references on plants, birds, mammals, and miscellaneous topics also is provided. (Author abstract)

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Habitat development field investigations, Nott Island Upland Habitat Development Site, Connecticut River, Connecticut. Summary report. L. Jean Hunt, B. R. Wells, Alfred W. Ford. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, August 1978. Technical Report D-78-25 (NTIS No. AD-A059 725).

Habitat development activities following placement of dredged material from the Connecticut River in 1975-1976 in an upland disposal site on Nott Island, 10 km upriver from Long Island Sound, are summarized. The sediments were fertilized and limed and planted with legumes and grasses in late summer 1976. Botanical and soil measurements were taken through 1977 to monitor success of vegetation establishment and evolution of soil conditions. Wildlife use of the site was documented and compared with baseline data. Aspects of engineering, botany, soils, and wildlife are discussed. Dredging and disposal operations were typical of maintenance projects in the area, with the exception that much of the activity had to be done in winter when weather conditions hindered the work. The sediments made a rather harsh environment for establishment of some domestic plant species; soil salinity was high and acidity low. Grasses established themselves and grew better than legumes and achieved 80 percent cover. Wildlife response to vegetation establishment was evident primarily through feeding activity. 18 references. (Author abstract modified) Appendices to this report represent the following individual studies which provided the data base upon which much of this Summary Report was developed. Appendix A: Preliminary terrestrial ecological survey, by R. S. Warren and W. A. Niering, University of Connecticut, Storrs, Connecticut (reproduced on microfiche and enclosed in the Summary Report). Appendix B: Survey by R. S. Warren, et al., University of Connecticut, Storrs, Connecticut (reproduced on microfiche and enclosed in the Summary Report). Appendix C: Postpropagation monitoring of vegetation and wildlife, by W. J. Barry, et al., University of Connecticut, Storrs, Connecticut (printed report). Appendix C is abstracted below.

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Habitat development field investigations, Nott Island Upland Habitat Development Site, Connecticut River, Connecticut. Appendix C: Postpropagation monitoring of vegetation and wildlife. William J. Barry, R. Scott Warren, William A. Niering, Joan L. Tabachnick, Allen C. Carroll. Storrs, CT, University of Connecticut, August 1978. Technical Report D-78-25 (NTIS No. AD-A059 725)

Two experimental areas were delineated on the site and monitored for plant establishment and growth. The first consisted of 96 experimental plots test planted with one of six plant species (tall fescue, timothy, orchard grass, ryegrass, red clover, and white clover), fertilized, and experimentally limed. The second was the remainder of the disposal area which was fertilized, limed, and planted with a mixture of clover and tall fescue. Wildlife use of the site was determined through small mammal trapping, a bird breeding survey, and combined transect-observation station counts.

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Habitat development field investiations, Bolivar Peninsula Marsh and Upland Habitat Development Site, Galveston Bay, Texas. Summary report. Hollis H. Allen, Ellis J. Clairain, Jr., Robert J. Diaz, Alfred W. Ford, L. Jean Hunt, B. R. Wells. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, August 1978. Technical Report D-78-15 (NTIS No. AD-A063 780).

A 2.5-year field investigation was conducted at Bolivar Peninsula, Galveston Bay, Texas, to test the feasibility and impact of developing marsh and upland habitats on dredged material. This report summarizes baseline information derived before habitat development operations and the results of postdevelopment operations. Two marsh grass species and nine upland plant species including trees, shrubs, and grasses were planted in test plots on a dredged material site lying between the Gulf Intracoastal Waterway and Galveston Bay. Tests were conducted to measure plant survival and performance in response to different fertilizer treatments and planting methods. Plantings were successful in both marsh and upland. Marsh grasses surviving and performing well included smooth cordgrass (*Spartina alterniflora*) and salt meadow cordgrass (*Spartina patens*). Upland plants demonstrating good survival and growth were live oak (*Quercus virginiana*), wax myrtle (*Myrica cerifera*), winged sumac (*Rhus copallina*), bitter panicum grass (*Panicum amarum*), and coastal bermuda grass (*Cynodon dactylon* var *alecia*. Components of the habitat development site, consisting of the planted vegetation and sandbag dike, attracted insects, aquatic organisms, and birds. After less than a year of development, the site provided heterogeneous habitats which tended to support greater use by fish and benthos than is generally associated with sandy shores along the Bolivar Peninsula. 36 references. (Author abstract modified) Appendices to this report represent the following individual studies which provide the data base upon which this summary report was developed: Appendix A: Baseline inventory of water quality, sediment quality, and hydrodynamics, by J. D. Lunz, E. J. Clairain, Jr., and J. W. Simmers, Environmental Laboratory, U.S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Mississippi (reproduced on microfiche and enclosed in the Summary Report). Appendix B: Baseline inventory of terrestrial flora, fauna, and sediment chemistry, by J. D. Dodd, D. J. Herlocker, B. W. Cain, B. J. Lee, L. R. Hossner, and C. Lindau, Texas A&M University, College Station, Texas (reproduced on microfiche and enclosed in the Sumary Report). Appendix C: Baseline inventory of aquatic biota, by J. M. Lyon and K. N. Baxter, National Marine Fisheries Service, Galveston, Texas (reproduced on microfiche and enclosed in the Summary Report). Appendix D: Propagation of vascular plants and postpropagation monitoring of botanical, soil, aquatic biota, and wildlife resources, by J. W. Webb, J. D. Dodd, B. W. Cain, W. R. Levens, L. R. Hossner, C. Lindau, R. R. Stickey, and H. Williamson, Texas A&M University, College Station, Texas (printed report). Appendix D is abstracted below.

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Habitat development field investigations, Bolivar Peninsula Marsh and Upland Habitat Development Site, Galveston Bay, Texas. Appendix D: Propagation of vascular plants and postpropagation monitoring of botanical, soil, aquatic biota, and wildlife resources. June 1978. Technical Report D-78-15 (NTIS No. AD-A063 780).

Post development monitoring activities are summarized. Plant survival and performance in response to different fertilizer treatments and planting methods were measured. Soil parameters were analyzed and related to plant growth. Aquatic biota was monitored for invasion and composition. Wildlife observations were made to determine reptile, amphibian, mammal, and bird use of the site.

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Habitat development field investigations, Miller Sands Marsh and Upland Habitat Development Site, Columbia River, Oregon. Summary Report. Ellis J. Clairain, Jr., Richard A. Cole, Robert J. Diaz, Alfred W. Ford, Robert T. Huffman, L. Jean Hunt, B. R. Wells. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, November 1978. Technical Report D-77-38.

A two and one-half year field investigation conducted at Miller Sands Island, a tidal freshwater, dredged material disposal site in the Columbia River, Oregon, is summarized. The field study was conducted to determine the feasibility of developing productive marsh and terrestrial wildlife habitat on dredged material and to determine if development of wildlife habitat is a viable alternative to other dredged material disposal options. This report synthesizes baseline information obtained before habitat development operations and the results of postdevelopment operational studies. Plantings were generally successful in both the intertidal and upland areas. The intertidal plantings provided habitat for aquatic and terrestrial animal communities but did not greatly improve or damage animal populations. The planted upland areas were used by waterfowl more than upland reference areas, although the number of avian species was less. 28 references. (Author abstract modified). Appendices to this report represent the following individual studies which provided the data base upon which this summary report was developed. Appendix A: Inventory and assessment of predisposal physical and chemical conditions, by N. Cutshall and V. G. Johnson, Oregon State University, Corvallis, Oregon (reproduced on microfiche and enclosed in the Summary Report); Appendix B: Inventory and assessment of predisposal and postdisposal aquatic habitats, by R. J. McConnell, et al., National Marine Fisheries Service, Seattle, Washington (reproduced on microfiche and enclosed in the Summary Report); Appendix C: Inventory and assessment of prepropagation terrestrial resources on dredged material, by C. D. White, et al., Woodward-Clyde Consultants, Portland, Oregon (reproduced on microfiche and enclosed in the Summary Report); Appendix D: Propagation of vascular plants on dredged material, by W. F. Ternyik, Wave Beach Grass Nursery, Florence, Oregon (reproduced on microfiche and enclosed in the Summary Report); Appendix E: Postpropagation assessment of botanical and soil resources on dredged material, by P. E. Heilman, et al., Washington State University, Pullman, Washington (printed report); and Appendix F: Postpropagation assessment of wildlife resources on dredged material, by J. A. Crawford and D. K. Edwards, Oregon State University, Corvallis, Oregon (printed report). Appendices E and F are abstracted below.

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Habitat development field investigations, Miller Sands Marsh and Upland Habitat Development Site, Columbia River, Oregon. Appendix E: Postpropagation assessment of botanical and soil resources on dredged material. August 1978. Technical Report D-77-38 (NTIS No. AD-A062 261).

Development of soil characteristics and planted marsh and upland vegetation were examined at Miller Sands Island, a dredged material disposal site in the Columbia River, Oregon. Soil analyses showed uniform soil conditions with sandy textures. The soil was also very low in organic matter and nitrogen but had relatively high base status and pH. The phosphorus level was higher than levels found in adjacent natural soils. Although marsh soils were somewhat less oxidized at lower elevations, the soil was relatively well aerated and contained no sulfides or nitrates. Plant growth and survival in the marsh indicated significant effects of elevation with almost no plants surviving in the lowest elevations planted. Aerial biomass production in the planted marsh was over five times greater than in the unplanted beach area, but about one-third as great as the natural marsh area. Fertilization significantly increased growth, seed production, and biomass of *Deschampsia cespitosa*, but had no effect on *Carex obnupta*. Good plant growth was obtained with most species planted on the upland area. Fertilization was necessary for the establishment of most upland species even though competition from invading grasses greatly increased with application of fertilizer. Barley, red clover, white clover, and bentgrass produced flowers after the first year of growth, but seed production was poor.

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Habitat development field investigations, Miller Sands Marsh and Upland Habitat Development Site, Columbia River, Oregon. Appendix F: Postpropagation assessment of wildlife resources on dredged material. May 1978. Technical Report D-77-38 (NTIS No. AD-A056 873).

Wildlife response to plant propagation on Miller Sands Island, a dredged material disposal site in the lower Columbia River, was assessed from July 1976 through August 1977. Plant establishment was accomplished in late summer and fall of 1976. Data on birds, mammals, and terrestrial macroinvertebrates were collected, analyzed, and compared with data from other regions of the United States. Six habitat types were examined: natural beach, marsh, upland, and tree-shrub

planted marsh; and planted upland. The planted marsh was used by fewer bird species than was a reference marsh; however, a trend developed near the end of the study which indicated that use of both will eventually be similar. Upland plantings apparently increased the diversity and number of species which used adjacent upland areas. Waterfowl fed and nested in the upland plantings, preferring a barley/bentgrass/red clover mix for feeding and a reed canary grass/red fescue/hairy vetch mix for nesting. Very few small mammals were trapped, but it appeared that the Townsend's vole population increased in the upland canary grass/fescue/vetch mix. Macroinvertebrate populations increased on the upland. Plantings did not have dramatic effects on the animal populations monitored. Avian density and diversity were mostly unaffected. But in some instances, the number and type of species changed in response to the plantings.

CHAPTER 9: PRODUCTIVE USES OF DREDGED MATERIAL

Upland Disposal and Land Improvement Concepts

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Productive uses of spoil. In: *Disposal of dredge spoil: problem identification and assessment and research program development,* pp. 100-109. November 1972. Technical Report H-72-8.

Following a discussion of the possibility of using spoil to create artificial wildlife habitat islands and marshes, the use of spoil for landfill operations, subsidence and erosion control, mine and pit filling, agricultural land development and enhancement, and development of products such as bricks and building materials is considered. For an overall summary of Technical Report H-72-8, see abstract no. 22.

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Land application of waste materials from dredging, construction, and demolition processes. Charles R. Lee, Robert M. Engler, Jerome L. Mahloch. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Effects Laboratory, June 1976. Miscellaneous Paper D-76-5 (NTIS No. AD-A026 842).

The text of a manuscript to be published as a chapter in a monograph of the symposium entitled 'Land Application of Waste Materials,' sponsored by the Soil Conservation Society of America, is presented. The paper is divided into two sections: waste materials generated by the dredging process, and those generated by the construction and demolition processes. Quantities and the general physical and chemical characteristics of the waste materials for each process are described. The potential use of these materials for land application for agricultural production is discussed, and other potential uses such as land improvement, wildlife habitat development, recreational facilities, and industrial and residential landfill are examined. The environmental impact of using these materials is described, with emphasis on the legal restrictions and social and psychological concerns to be considered. 42 references (Author abstract)

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Feasibility of inland disposal of dewatered dredged material: a literature review. Long Beach, CA, SCS Engineers, November 1977. Technical Report D-77-33 (NTIS No AD-A048 203).

A literature review of all factors affecting dredged material disposal in inland areas is presented. The physical and chemical characteristics of dredged material, inland dredged material disposal site selection and preparation problems and procedures, basic information presented in the General Research Corp. study of transportation systems for the inland disposal of dredged material, information on inland disposal of dredged material, the total costs of a disposal site, potential environmental problems associated with the disposal of polluted dredged material and possible controls available, social factors affecting the feasibility of inland disposal, institutional constraints affecting its feasibility, and final site use as it affects feasibility are discussed in separate sections. The major findings are that inland disposal is feasible and that sites can be designed and operated in a manner which is *environmentally sound and socially compatible.* However, minor operational problems may be encountered which can be identified only after some field testing of the criteria. Furthermore, there is insufficient data available concerning the quality and quantity of leachate expected from land deposited dredged material to permit an accurate engineering design of control systems. 77 references. (Author abstract modified) For a separate section of this report, see the following abstract

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Checklist for determining potential inland disposal sites. In: *Feasibility of inland disposal of dewatered dredged material: a literature review,* pp. 109-146. November 1977. Technical Report D-77-33

A checklist providing a step-by-step planning process for inland confined disposal area selection and final site use is presented. It is intended for use as a decision-making tool by officials who must provide inland sites for the final disposal of polluted dredged material and by officials who are required by state and/or local agencies to develop a site plan or who must meet specific end use requirements. The planning process

considers all factors necessary to provide a cost-effective disposal site that is environmentally and socially compatible with its surroundings. The checklist is divided into three sections which together identify a broad range of project and disposal site information to be collected and reviewed: (1) a format for gathering general information about the dredging project; (2) site-specific background data for each candidate final site identified in the first section; and (3) six basic categories relating to the feasibility of site use for the disposal of dredged material (land use information and institutional constraints, physical features, technical considerations, environmental and social impacts, public attitudes, and economic factors). An accompanying flow chart illustrates the checklist organization and the interrelation among the three sections. For an overall summary of Technical Report D-77-33, see abstract no. 278.

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Dredged material transport systems for inland disposal and/or productive use concepts. Paul S. Souder, Jr., Leo Tobias, J. F. Imperial, Frances C. Mushal. McLean, VA, General Research Corp., June 1978. Technical Report D-78-28 (NTIS No. AD-A058 432).

The results of a study designed to identify and evaluate transportation systems applicable for the movement of dredged material inland are presented. As such, this report is intended to provide the U.S. Army Corps of Engineers with generalized data to be used in evaluating the economic potential of inland disposal alternatives for specific applications across the country. Considerable detail is provided from both a technical and economic point of view to allow the users of this report to apply the information presented to their particular situations. Five basic transportation modes were examined: pipeline slurry, rail haul, barge movement, truck haul, and belt conveyor movement. Combinations of these basic modes have been considered where appropriate. In this study, the only transportation mode that is examined for the movement of a slurry mixture is the pipeline alternative. For the pipeline movement of dredged material in a slurry state, varying slurry and in situ densities are examined. The other transportation modes are concerned with the movement of relatively dry material. The results presented have been developed for a generalized application of the movement of dredged material from point A to point B anywhere across the country and are to be used as a guide in transportation costs for a given situation. Appendices contain (1) a review of the relationship between dredging operations and the long-distance transport system and (2) computer outputs for the most [illegible] references. Selected bibliography of 161 [illegible] modified)

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Use of dredged material in solid waste management. Final report. Michael J. Bartos. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Effects Laboratory, September 1977. Technical Report D-77-11 (NTIS No. AD-A045 509).

The feasibility of using dredged material in solid waste management was investigated from the standpoint that dredged material could be used to replace natural soil as borrow or to create land on which to locate solid waste disposal operations. The suitability of dredged material at sanitary landfills for uses as cover, gas barriers and vents, impervious liners, and leachate collection underdrains was studied by comparing dredged material properties with the properties of soils known to be suitable. It is concluded that coarse-grained dredged material is suitable for vent decomposition gases and leachate collection. Fine-grained or mixed-grained materials are shown to be suitable as gas barriers, impervious liners, and covers. Appendices to this report present brief descriptions of (1) the solid waste management operations discussed in the report and (2) hydraulic dredging, dredged material containment, and dredged material dewatering.

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The agricultural value of dredged material. S. C. Gupta, W. E. Larson, R. G. Gast, Sherry M. Combs, R. H. Dowdy St. Paul, MN, U.S. Department of Agriculture, Agricultural Research Service, North Central Region, July 1978. Technical Report D-78-36 (NTIS No. AD-A061 298)

To study the suitability of dredged material for crop production, 10 dredged material samples and 10 marginal soil samples were collected from locations in the United States. The soils were marginal for crop production and were of such character that additions of dredged material might improve their physical and chemical properties. In addition, three productive Minnesota soils were chosen as controls. Samples of the dredged material, marginal soil and mixtures of the two were physically and chemically analyzed prior to and after plant growth (production) experiments with three crops of ryegrass and barley. In general, chemical properties of the dredged material samples did not differ greatly from the chemical properties of the three productive soils from Minnesota. Three cuttings of ryegrass and two crops of barley were harvested from each of the treatments. Yields by plants in the greenhouse were greater for all fine-textured dredged material samples as compared to the coarse-grained marginal soils. Elemental analysis of the plant samples showed that, with the possible exception of boron in Alabama dredged material, none of the elemental concentrations were high enough to be toxic to plants. It is concluded that the dredged material used in this study would be beneficial for increasing agricultural production when mixed with marginal soils. Relationships between uptake and the availability of various soil elements were developed that can offer guidance in setting the ratio of dredged material to marginal soil to be used in the field

Physical and chemical data, along with the plant growth data, were used to develop guidelines for the disposal of dredged material on marginal soils. Appendices to this report give: (1) physical characteristics of dredged material, marginal soil, and their mixtures; (2) clay mineral analyses; and (3) elemental analyses of plants studied. 74 references. (Author abstract modified)

Disposal Area Land-Use Concepts

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Socioeconomic aspects of dredged material disposal: the creation of recreation land in urban areas. Stephen S. Skjei. Charlottesville, VA, University of Virginia, May 1976. Contract Report D-76-6 (NTIS No. AD-A027 554).

The legal, institutional, sociological, and economic factors affecting the recreational use of dredged material disposal sites are presented, with emphasis placed on the factors which would constrain the creation of shoreline or offshore recreational land. Factors influencing supply of and demand for outdoor recreational facilities are discussed. The National Environmental Policy Act of 1969, the Fish and Wildlife Coordination Act, and the Coastal Zone Management Act are reviewed in detail to determine what effect they would have on the recreational use of dredged material sites. The activity-specific (market-demand) approach, used to estimate benefits for recreational facilities which could be created from dredged material, is described and applied to proposed recreational uses of dredged material disposal sites in Baltimore, the New York region, and the Los Angeles Harbor. Findings indicate that dredged material can be used in an economically feasible manner, that derived benefits would be substantial, and that environmental concerns are not insurmountable. However, financial resources available to local communities could be an important constraint. Appendices to this report present (1) a summary of the problems and practices associated with dredged material disposal for selected Corps of Engineer Districts and (2) the procedures used to estimate benefits from the recreational use of dredged material. 104 references. For separate sections of the report, see the following three abstracts.

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Current practices and procedures of the Corps of Engineers. In: *Socioeconomic aspects of dredged material disposal: the creation of recreation land in urban areas,* pp 39-65. May 1976. Contract Report D-76-6.

Policy areas which would appear to require modification or adjustment if the recreational use of dredged material disposal sites became widespread are reviewed. The permit process, general authorization, disposal site acquisition and development, site selection, and the relationship between the Corps of Engineers and other Federal and State agencies are the major topics discussed. For an overall summary of Contract Report D-76-6, see abstract no. 283.

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Institutional factors. In: *Socioeconomic aspects of dredged material disposal: the creation of recreation land in urban areas,* pp. 94-105. May 1976. Contract Report D-76-6.

The most important formal or institutionalized aspects of using dredged material for recreational purposes are discussed. These include: financial aid programs (Land and Water Conservation Fund, national urban parks, programs of the Department of Housing and Urban Development, Corps programs, and other Federal programs), State programs, mechanisms for intergovernmental cooperation, and State regulatory legislation. For an overall summary of Contract Report D-76-6, see abstract no. 283.

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Sociological issues. In: *Socioeconomic aspects of dredged material disposal: the creation of recreation land in urban areas,* pp. 106-130. May 1976. Contract Report D-76-6.

The most important sociological issues surrounding the recreational use of dredged material disposal sites were analyzed in the context of two cities, Baltimore and Norfolk. Following an analysis of the distribution of recreational resources in both cities, the use and abuse of selected facilities in each location were studied. Regression analysis was used to determine the extent to which variance in the variable 'vandalism' could be accounted for by a combination of recreation variables, neighborhood factors, and distance from city center. Neighborhood factors appear to be of central importance in explaining vandalism at recreational facilities. For an overall summary of Contract Report D-76-6, see abstract no. 283.

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Case studies and comparative analyses of issues associated with productive land use at dredged material disposal sites. Volume I: Main text. Volume II: Appendices A–R. [1]John J. Gushue, [2]Kenneth M. Kreutziger, [1]Cambridge, MA, Energy Resources Company, Inc., [2]Watertown, MA, Susaki Associates, Inc., December 1977. Technical Report D-77-43 (NTIS Nos. AD-A055 386, Volume I, AD-054 893, Volume II).

Twelve case studies of confined disposal sites where dredged material from navigation projects was used to create productive land are presented. The case studies were prepared to examine multi-objective disposal-productive use planning in terms of: (1) the sequence of events comprising the planning and implementation process, (2) participants in project plan

ning/review and their roles and interactions; (3) issues addressed during project planning/review, their importance, and how they were solved; (4) physical planning elements affecting the feasibility of disposal facility and productive land use plans; and (5) land use planning principles which should be reflected in proposed productive use concepts. This investigation produced a total list of 37 environmental, technical, economic/financial, legal, institutional, and planning implementation factors for productive use of dredged material confined disposal areas. The procedural aspects of each case study are delineated fully in individual case synopses contained in Volume II. Detailed comparative analyses of the cases also are included in Volume II. 186 references.

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A methodology for determining land value and associated benefits created from dredged material containment. E. T. Conrad, Andre J. Pack. Reston, VA, SCS Engineers, June 1978. Technical Report D-78-19 (NTIS No. AD-A061 841).

A step-by-step methodology for determining land values and associated benefits from the productive use of dredged material containment sites is presented. A discussion of *productive uses and an overview of property valuation*, including the basic steps involved in making appraisals for any type of property, are included. Fifteen case studies of productively used containment sites were conducted to validate and refine the methodology. One of the case studies was used in this report as a site- specific example of how the methodology can be applied. All 15 case studies are included as Appendices A through O. For separate sections of the report, see the following two abstracts. (Author abstract modified)

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Productive uses of dredged material sites. In *A methodology for determining land value and associated benefits created from dredged material containment*, pp 17-78, June 1978. Technical report D-78-19.

Development of a dredged material site is influenced by several considerations peculiar to the sites themselves, including site physical characteristics, institutional (legal) constraints, and local land demand. Each of these considerations is addressed. An accompanying table summarizes the productive uses of dredged material (industrial, commercial, municipal/institutional, residential, recreational, agricultural/horticultural, transportation, natural/open space, multiple use, and material use) in the United States. For an overall summary of Technical Report D-78-19, see abstract no. 288.

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Methodology for determination of land value and associated benefits. In: *A methodology for determining land value and associated benefits created from dredged material containment*, pp 36-75, June 1978. Technical Report D-78-19.

A four-part approach to estimating value changes and associated benefits or impacts created from dredged material confined disposal is presented. The first part is descriptive and places the site in the context of its physical, ecological, and legal environment. The second part seeks to ascertain the use potential for the site upon completion of placement operations. The third part deals with the determination of site value changes as the result of dredged material disposal. The final part identifies the associated benefits and impacts of confined disposal. The suggested methodology is not an appraisal procedure but a technique for deriving an estimate of value change to a site if it serves as a dredged material confined disposal site. An accompanying table lists environmental, economic, and social benefits and adverse impacts applied to the methodology. For an overall summary of Technical Report D-78-19, see abstract no. 288.

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Evaluation of laws and regulations impacting the land use of dredged material containment areas. James Cole, Michael Brainard. La Jolla, CA, Science Applications, Inc., Environmental Sciences Division, September 1978. Technical Report D-78-55 (NTIS No. AD-A063 905).

A survey approach was used in which Federal, State, and local laws, regulations, and ordinances that could significantly impact proposed uses of dredged material confined disposal areas were assembled for analysis. This survey included all Federal legislation, legislation from 16 states, and ordinances and regulations from selected cities and counties within these 16 states. All laws and regulations that were found which could have an impact on land use decisions, including procedures for preparation and review of environmental impact assessments, are summarized. The most restrictive provisions were incorporated into a series of scenarios for the application of permits to make productive uses of filled disposal areas, and these were analyzed to assist in the development of strategies for overcoming the legal constraints to end use of this land. The conclusions and recommendations include approaches to the incorporation of a disposal area location and end use element in the Level A, B, and C plans for river basins, produced under the *Federal Water Pollution Control Act 1972 Amendments* and the 1965 Water Resources Planning Act. The reader is urged to augment his reading with Technical Report D-78-20, the synthesis of research accomplished under Task 5(I). Appendices to this report contain: (1) the key word list used in research of State laws, (2) the hierarchy of laws and regulations of the Federal and State governments, (3) State land use law matrices, (4) the letter of request sent to cities, counties, and port districts, (5) the city and county land use constraints matrix, (6) the

matrix showing impact of port district authorities on land use; (7) the letter of request sent to U.S. Army Corps of Engineers Districts; (8) the matrix of Corps District responses; and (9) the collation of State laws by Corps District. 227-item bibliography. (Author abstract modified)

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Land use of dredged material containment areas: productive use examples. Ogden Beeman, Al P. Benkendorf. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory; Portland, OR, Beeman/Benkendorf, August 1978. Miscellaneous Paper D-78-4 (NTIS No. AD-A059 723).

Examples of productive land uses of dredged material confined disposal areas are documented. The examples, obtained from published literature and project descriptions and discussions with people knowledgeable in the planning and execution of dredging projects, are from 19 States and six foreign countries. The sites range from those filled over 50 years ago, which have been used productively for many years, to projects in various developmental stages. Projects are documented within the following land use categories: recreational, industrial/commercial, agricultural, institutional, material transfer, waterway related, and multiple purpose. Based on the examples cited and information analyzed during the study, the site selection process is discussed from historical and modern perspectives. Examples of recent processes and approaches to candidate site selection implemented by communities in the United States and abroad are described. The need of sponsors or developers to recognize and deal with a greater number of planning conditions to achieve greater land use intensity is underlined, and conclusions are drawn concerning the quality and quantity of literature available on productive land uses and the potential for achieving productive land uses on dredged material. Information sources are listed in the Appendix to the report. 16 references. 9-item bibliography. (Author abstract modified)

Marketable Products Development

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A feasibility study of lawn sod production and/or related activities on dredged material disposal sites. Cambridge, MA, Arthur D. Little, Inc., January 1975. Contract Report D-75-1 (NTIS No. AD-A006 609).

The technical and economic feasibility of using dredged material disposal sites for the commercial production of lawn sod, foliage plants, nursery products, Christmas trees, and vegetable and flower seeds and bulbs was studied. Findings argue against commercial production of horticulture crops on active dredged material disposal sites, but indicate the feasibility of establishing such production on mature sites, subject to certain constraints. Organizations contacted for the study are listed. 17 references. For separate sections of this report, see the following abstract.

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[The horticultural industry: planting and production. Marketing.] In: *A feasibility study of lawn sod production and/or related activities on dredged material disposal sites,* pp. 26-80. January 1975. Contract Report D-75-1.

Practices employed in the United States in planting and producing nursery products, foliage plants, lawn turf, Christmas trees, and vegetable and flower seeds are reviewed, and particular factors which potentially impact horticultural production on dredged material disposal sites are examined. Types of growers and developing influences on the horticultural industry are identified. Accompanying figures show the geographic distribution of major horticultural producing counties in the United States in 1970 and 1973. Changes occurring in the marketing of nonfood horticultural products are assessed, and market pressures which will further affect the industry are identified. Changes in the product mix of growers, in the distribution channels employed, and in the retail outlets through which these crops are sold are analyzed. The implication to be drawn is that a strong demand exists for land close to the marketplace that lends itself well to orderly production. For an overall summary of Contract Report D-75-1, see abstract no. 293.

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Field demonstration of shrimp mariculture feasibility in dredged material containment areas. J. A. Quick, Jr., D. J. Milligan, S. E. Hill, R. J. Hover, W. F. Mellhenny. Freeport, TX, Dow Chemical U.S.A., Texas Division, August 1978. Technical Report D-78-53 (NTIS No. AD-A062 652).

A field investigation was conducted to verify results of a previous small-scale study that showed some possibility for using confined disposal areas for shrimp mariculture. Seven hundred thousand juvenile shrimp were stocked in a 20-acre section of an existing 158-acre dredged material disposal area. Two months later the shrimp were harvested and tested for suitability for human consumption and for bait purposes. It is concluded that shrimp mariculture in confined disposal areas is technically feasible, although economic feasibility is still somewhat dependent on, among other things, a cheaper system of obtaining the stocking shrimp. The report presents a technical analysis and a complete economic analysis of the project, including projections of the probable acreage needed to make future ventures profitable. A recommended developmental program for attacking and solving the final prohibitive costs to commercialization of shrimp mariculture in confined disposal areas is appended. 80 references. (Author abstract modified)

CHAPTER 10: AQUATIC DISPOSAL FIELD INVESTIGATIONS

General Studies

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General research plan for the field investigations of coastal dredged material disposal areas. Paul R. Becker, Barry W. Holliday, Susan E. Palmer, Robert M. Engler. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Effects Laboratory, April 1975. Miscellaneous Paper D-75-13 (NTIS No. AD-A009 523).

The basic philosophy and general approach which will be used in a large-scale, interdisciplinary, field investigation program at four existing disposal areas in the Atlantic, Pacific, Gulf of Mexico, and Lake Erie coastal areas are outlined. The purpose of the research is to define adequately the environmental impact of the disposal of dredged material in open water. The basic objective of Phase I is to gather baseline data on the disposal sites and surrounding areas. A literature study will be conducted concurrently. The effects of open-water disposal of dredged material under controlled disposal conditions will be evaluated in Phase II. Results of the program, to be presented in Phase III, will include problem identification and delimitation and will establish the boundaries within which it is possible to predict impact and recovery if background information is given for the disposal site and the material to be disposed in it. Specific activities occurring in each phase and the actual duration of each period are described, and specific parameters to be investigated are detailed. (Author abstract modified)

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An assessment of the potential impact of dredged material disposal in the open ocean. Willis E. Pequegnat, David D. Smith, Rezneat M. Darnell, Bobby J. Presley, Robert O. Reid. College Station, TX, TerEco Corp., January 1978. Technical Report D-78-2 (NTIS No. AD-A053 183).

The potential physical, chemical, and biological impacts which may occur as a result of the disposal of dredged material in the deep ocean at and beyond the outer edge of the continental shelves of the United States and its possessions are assessed. A substantial part of the report is devoted to the selection and description of oceanic areas (not sites) off 11 subdivisions or sectors of the U.S. coasts in which specific disposal sites may be selected. The main body of the report considers deep ocean disposal environmental aspects, including: factors controlling spatial disposition and chemical fate of dredged material in the deep ocean, disposal environments in the deep ocean, environmental impacts of the disposal of dredged material in the deep ocean, hydrobiological zones as disposal environments, regional assessment of deep ocean disposal receiving environments, and suitability of specific environmental areas for disposal of dredged material. Appendices to the report contain (1) the roster of advisory panel members and (2) EPA 1977 ocean dumping regulations and criteria. 366 references. 426-item bibliography. (Author abstract modified) For separate sections of this report, see the following three abstracts.

298

Environmental aspects and impact of deep ocean dredged material disposal. In: *An assessment of the potential impact of dredged material disposal in the open ocean,* pp. 154-318, 529-566. January 1978. Technical Report D-78-2.

Physical, chemical, and biological aspects of deep ocean disposal of dredged material are examined, and the importance of long-term vs. short-term bottom influences is discussed. The location, hydrodynamics, and biodynamics of the marine disposal site are reviewed, and components and characteristics of marine ecological systems are detailed. Matter and energy transfers, the sea as an open ecosystem, and marine systems under stress are considered. The potential physical, chemical, and biological impacts of deep ocean disposal of dredged material at and beyond the outer edge of the continental shelves of the United States and its possessions are assessed. Finally, categories for ranking disposal areas are discussed, and the development of various physical oceanographic, chemical oceanographic, geomorphic/geologic, biologic, and other criteria for site selection is examined. These criteria are applied to the 11 deep ocean disposal sectors of the United States. For an overall summary of Technical Report D-78-2, see abstract no. 297.

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Nearshore-offshore ecological trends and zonal analysis. In: *An assessment of the potential impact of dredged material disposal in the open ocean,* pp. 319-382. January 1978. Technical Report D-78-2.

Some of the more important ecological trends are examined as a basis for zonal analysis. Trends in environmental and biological factors (phytoplankton, zooplankton, nekton, benthos) are considered. The outer continental shelf zone, continental slope zone, and continental rise-abyssal zone are analyzed as disposal environments. Geologic nature, currents and circulation, and biota are discussed for each zone. For an overall summary of Technical Report D-78-2, see abstract no. 297.

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Ecosystem dynamics and regional assessment of deep ocean disposal receiving environments. In: *An assessment of the potential impact of dredged material disposal in the open ocean,* pp. 382-527. January 1978. Technical Report D-78-2.

The dynamics of a single section of the ocean, thought of as 10 to 20 miles wide and extending across the outer continental shelf and into the abyss, are discussed. Topics covered include: the water section as an ecological unit, exchange processes, residence vs. transience of species, internal dynamics (production, consumption, and decomposition, as well as vertical and horizontal transport), system coordination and regulation, and geographic variation. In addition, the geomorphology, oceanography/meteorology, and fisheries resources of the various deep ocean disposal sectors of the United States are examined. Gulf Coast, Atlantic Coast, and Pacific Coast sectors and sectors of minor importance (Alaska, Hawaii, and the U.S. Caribbean territories) are considered. For an overall summary of Technical Report D-78-2, see abstract no. 297.

Eatons Neck (New York) Field Study

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Aquatic disposal field investigations, Eatons Neck disposal site, Long Island Sound; an environmental inventory. Stephen P. Cobb, J. R. Reese, Mitchell A. Granat, Barry W. Holliday, E. H. Klehr, Joe H. Carroll. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, May 1978. Technical report D-77-6 (NTIS No. AD-A055 217)

The Eatons Neck (Long Island Sound, New York) disposal site field investigation, conducted to evaluate the effects of aquatic disposal of dredged material on organisms and water quality, is described. The study was intended to determine the significance of physical, chemical, and biological factors which influence the rate of disposal site recolonization by benthic animals. Due to local opposition to the proposed research and dredging operation, however, the study was terminated at the conclusion of the baseline studies. The resulting data on the hydraulic regime, meteorology, sediment chemistry, water chemistry, plankton, benthos, and demersal fish and shellfish at the site were used to describe the environment at the site and surrounding areas and to make limited assessments of the effects of more than 70 years of disposal. This report provides previously unpublished results, interpretations, and conclusions not found in the appendices, which were reproduced separately. The appendices (abstracted below) cover (1) the investigation of the hydraulic regime and the physical characteristics of bottom sedimentation, (2) water-quality parameters and physicochemical sediment parameters, and predisposal baseline conditions of (3) benthic assemblages; (4) demersal fish assemblages; (5) zooplankton assemblages; and (6) phytoplankton assemblages. 41 references. (Author abstract modified)

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Aquatic disposal field investigations, Eatons Neck disposal site, Long Island Sound. Appendix A: Investigation of the hydraulic regime and the physical characteristics of bottom sedimentation. Henry Bokuniewicz, Catherine Bultman, Michael Dowling, Jeffrey Gebert, Robert Gordon, Peter Kaminsky, Carol Pilbeam. New Haven, CT, Yale University, Department of Geology and Geophysics, September 1977. Technical Report D-77-6.

This volume presents the results of the investigation of the hydraulic regime and the physical characteristics of bottom sedimentation of the Eatons Neck disposal site. Acoustic reflection profiles and mechanical analysis of core and grab samples of the bottom were used to define the sediment type distribution of the area. Results were confirmed by penetrometer tests and bottom and profile photographs. Since the study was made to determine the possible movement of dredged material placed on the bottom, the currents were studied using both averaging and instantaneous recording current meters. The study concluded that there was no physical evidence of significant dispersion of dredged material from the Eatons Neck disposal site; no previously deposited material was detected outside the designated disposal area. Appendix A details navigation procedures and permanent buoy construction used in the study. Appendix B consists of the 16 reflection profile photos. Sediment analysis data are presented in Appendix C. Appendix D shows the profile camera photos and Appendix E shows the bottom photos.

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Aquatic disposal field investigations, Eatons Neck disposal site, Long Island Sound. Appendix B: Water-quality parameters and physicochemical sediment parameters. Stony Brook, NY, State University of New York at Stony Brook, Marine Sciences Research Center, January 1978. Technical Report D-77-6.

Seven oceanographic cruises and three sediment coring cruises were conducted in western Long Island Sound to assess the baseline water column and sediment properties near the Eatons Neck disposal site. The following points summarize the main findings: (1) Water chemistry data indicated that there were various types of spatial gradients in the central sound. However, it appeared that factors other than the presence orf dredged material at the disposal site, e g , river dischages containing sewage effluents and other chemicals, could explain these gradients. There appeared to be no major differences in chlorophyll *a*, dissolved oxygen, and dissolved and suspended metals between reference station A and disposal site station DSA. Particulate carbon and nitrogen were higher at the reference station than at the disposal site in March and May. However, interpretations of the water chemistry data are unclear because daily temporal variation was not adequately separated from spatial variation due to a lack of synoptic data. (2) There were no significant differences between reference station A and the disposal site stations for sediment mineralogy, bulk sediment, and interstitial water metals (with the possible exception of zinc and manganese), oil and grease, and cation exchange capacity. Ammonia, organic carbon, organic nitrogen, and pH, however, were all higher in the sediments at the disposal site than at the reference station. Sediments at the reference station were more fine grained in the upper 10 cm than at the disposal site. These differences are probably due to the larger amounts of organic matter in dredged material at the disposal site. No dissolved oxygen depletion was noted in the bottom water at the disposal site, however. (3) It appears, in summary, that any effects of the presence of dredged material at the site on nutrients, metals, and other chemical variables in the central sound are minimal and are probably overshadowed by effects of sewage effluents and other river inputs.

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Aquatic disposal field investigations, Eatons Neck disposal site, Long Island Sound. Appendix C: Pre-disposal baseline conditions of benthic assemblages. D. Keith Serafy, David J. Hartzband, Marcia Bowen. Montauk, NY, New York Ocean Science Laboratory, November 1977. Technical Report D-77-6.

Data from a baseline survey of macrobenthic and meiobenthic assemblages inhabiting the disposal site and immediate vicinity of western Long Island Sound were used to describe the benthic assemblages of a disposal site that had received dredged material and other substances for a period of about 71 years, 1902 to 1973. No dumping had taken place at the site for about one year prior to collection of the baseline data. The silt-clay or mud sedimentary environment is the largest benthic habitat in the Eatons Neck disposal site, extending over most of the site except in the vicinity of reefs. The mud sediments harbor a relatively distinct macrobenthic assemblage dominated numerically by the polychaetes *Mediomastus ambiseta* and *Nephtys incisa* and the bivalves *Mulinia lateralis* and *Nucula proxima*. In the sandy environment of Budd Reef in the northern corner of the site, the crustacean *Hutchinsoniella macracantha*, and polychaetes *M. ambiseta* and *N. incisa*, the bivalve *Tellina agilis*, and the nemertean *Tubulanus pellucidus* were the most abundant secies. The sand assemblage occurring at Cable and Anchor Reef in the extreme eastern section of the site was dominated by the annelids *M. ambiseta*, *Aricidea cirruti*, and *Polygordius triestinus*, oligochaetes, nematodes, the bivalve *T. agilis*, and the amphipods *Ampelisca vadorum* and *Phoxocephalus holbolli*. *The mud assemblage generally had lower species diversity, biomass, and density of macroinvertebrates than the two sand assemblages. Deposit feeders were typically the most abundant species in all assemblages. Temporal changes occurred in benthic species composition and abundance. The meiobenthos was dominated by nematodes and harpacticoid copepods.*

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Aquatic disposal field investigations, Eatons Neck disposal site, Long Island Sound. Appendix D: Pre-disposal baseline conditions of demersal fish assemblages. Robert J. Valenti, Stephen Peters. Montauk, NY, New York Ocean Science Laboratory, September 1977. Technical Report D-77-6.

This report presents demersal fish sampling data at the Eatons Neck disposal site. The spatial and temporal distributions of the more abundant demersal fish are discussed. The food habits of eight benthic foraging fish species are also presented. Data on lobsters include monthly histograms denoting spatial and temporal distributions, male-female ratios, and relative abundance of exploitable legal-sized lobsters. The report concludes that the disposal site is a valuable area with regard to fishery resources. Throughout the sampling, with few exceptions, the site accounted for the largest catches of fish. It was also found to be a prime lobstering area and accounted for 91.3 percent of the total number of lobsters collected. The study recommends that prime consideration be given to lobster fishery in any future disposal operations since it represents the most utilized resource of the area.

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Aquatic disposal field investigations, Eatons Neck disposal site, Long Island Sound. Appendix E: Pre-disposal baseline conditions of zooplankton assemblages. Ronald I. Caplan. Montauk, NY, New York Ocean Science Laboratory, September 1977. Technical Report D-77-6.

A zooplankton and ichthyoplankton study was initiated in October 1974 for the purpose of establishing a baseline data

bank at the Eatons Neck disposal site. A control site was also studied. During the 9-month study, a total of 147 samples were taken at each of three stations (two disposal sites and one control). Concomitantly, temperature and salinity profiling was done. *Acartia tonsa* was common throughout the first 6 months of the study with densities as high as 500,000 individuals/1000 m^3. A plankton bloom occurred in populations of several copepods (including copepodids), *Acartia clausii, Temora longicornis,* and, *Acartia* spp. copepodids. Meroplanktonic Crustacea, Caridia (shrimp), and Brachyura (crabs) became abundant (greater than 100,000 individuals/1000 m^3) in April and May, respectively. There were two blooms of Cladocera during 1975, one in February (1000 individuals/1000 m^3) and one in June (1,000,000 individuals/1000 m^3). *Evadne* sp. dominated the first bloom, and *Podon* the second. Polychaeta larvae were not common at any time during the study. The first fish eggs obtained in this study were collected in February 1975 at both control and disposal sites. They belonged to the four-bearded rockling, *Enchelyopus cimbrius*. Larvae of the winter flounder, *Pseudopleuronectes americanus,* and the sand lance, *Ammodytes hexapterus,* were also collected with the former being present at the control site only. The spring pattern of ichthyoplankton abundance included the eggs of *Enchelyopus cimbrius, Scomber scombrus,* and *Scopthalmus aquosus*. *Myoxocephalus* spp. and *Pseudopleuronectes americanus* larvae were also collected. The summer ichthyoplankton fauna included nine species of eggs and larvae with the first appearance of the butterfish, *Peprilus triacanthus*. The winter patterns of copepod abundance indicated two important findings. (1) There was a copepod bloom in December 1974, 6 weeks before the spring diatom bloom. (2) Copepod densities were maximum at depth during the November diurnal, indicating a reproductive strategy not previously reported.

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Aquatic disposal field investigations, Eatons Neck disposal site, Long Island Sound. Appendix F: Pre-disposal baseline conditions of phytoplankton assemblages. Robert Nuzzi. Montauk, NY, New York Ocean Science Laboratory, September 1977. Technical Report D-77-6.

This volume presents the results of an investigation to determine the baseline conditions of the phytoplankton population at the disposal site for future comparison with similar data collected after the disposal of dredged material. The ultimate objective is to determine the effects of the open-water disposal of dredged material on the phytoplankton population located within the area of the Eatons Neck disposal site. By using the Shannon-Weaver and the Simpson indexes it was determined that little variation existed in the diversity of the phytoplankton population at each station (EN1, EN2, and EN3) and depth measured. The exception to this occurred in the October and June sampling periods when stations EN1 and EN2 showed distinctly different diversities for the surface, middepth, and near-bottom samples. The diversity of the population at station EN3 was approximately equal for each depth. The study concludes that, although it is difficult to draw any conclusions prior to a more thorough statistical analysis, it appears that there is little difference in the composition and abundance of the phytoplankton found at the three stations.

Columbia River (Oregon) Field Study

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Aquatic disposal field investigations, Columbia River disposal site, Oregon. Evaluative summary. Charles G. Boone, Mitchell A. Granat, Michael P. Farrell. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, May 1978. Technical Report D-77-30 (NTIS No. AD-A056 925).

An overview of a study conducted to determine the physical, chemical, and biological effects of open-water disposal of dredged material in the nearshore Pacific Ocean adjacent to the mouth of the Columbia River in Oregon is presented. The investigation also involved the monitoring of dredged material disposal at a designated disposal site and an estimation of the short-term impacts of the disposal operation and the subsequent recolonization of the area. Conclusions indicate that the disposal effects were mainly physical and biological in nature. Appendices to the report (abstracted below) describe (1) the investigation of the hydraulic regime and physical nature of bottom sedimentation, (2) water column, primary productivity, and sediment studies, (3) the effects of dredged material disposal on benthic assemblages, (4) zooplankton and ichthyoplankton studies, and (5) demersal fish and decapod shellfish studies. 27 references.

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Aquatic disposal field investigations, Columbia River disposal site, Oregon. Appendix A: Investigation of the hydraulic regime and physical nature of bottom sedimentation. Richard W. Sternberg, Joe S. Creager, William Glassley, Janice Johnson. Seattle, WA, University of Washington, Department of Oceanography, December 1977. Technical Report D-77-30.

A two-part study was conducted in a region seaward of the Columbia River where disposal of large quantities of dredged material has occurred over the last several decades. The first part included repeated bathymetric surveys and sampling for distribution and seasnoal variations of sediment texture and mineralogy. The second part was related to an experiment in which 600,000 cu yd of material dredged from the Columbia River estuary were dumped at a specially designated site which was monitored before, during, and after disposal. Sedimentological data show that deposits of dredged material can be identified relative to the surrounding sediments. They tend to maintain their identity for many years and disperse northward at approximately 0.3 nmi per year. At the experimental disposal site the volume of the bottom deposit was 6.1 percent of the total material dumped. Calculations of bedload

transport rates, based on seasonal measurements of bottom currents, suggest that 830 cu yd of material (0.2 percent of the total) spread northward from the site about 0.25 nmi per year. This is similar to the rates determined by the sedimentological techniques. The coherent and complementary nature of the results emphasizes the value of combining both descriptive sedimentological techniques and measurements of oceanic processes for monitoring and predicting the fate of dredged material. For an evaluative summary and interpretation of all studies conducted at the field site, see abstract number 308.

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Aquatic disposal field investigations, Columbia River disposal site, Oregon. Appendix B: Water column, primary productivity, and sediment studies. Robert L. Holton, Norman H. Cutshall, Louis I. Gordon, Lawrence F. Small. Corvallis, OR, Oregon State University, School of Oceanography, June 1978. Technical Report D-77-30.

This appendix describes the study plan and the sampling and analytical methods used for water column, primary productivity, and sediment quality investigations of dredged material disposal in the Pacific Ocean near the mouth of the Columbia River. Few data are presented since the data are stored in the computer at the U.S. Army Engineer Waterways Experiment Station. However, some of the data are summarized in figures included in this report. The study concludes that the disposal of clean sand in an open-water area has little effect on the levels of the various potential pollutants, either in the water column or in the sediments in the disposal area. For an evaluative summary and interpretation of all studies conducted at the field site, see abstract number 308.

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Aquatic disposal field investigations, Columbia River disposal site, Oregon. Appendix C: The effects of dredged material disposal on benthic assemblages. Michael D. Richardson, Andrew C. Carey, William A. Colgate. Corvallis, OR, Oregon State University, School of Oceanography, December 1977. Technical Report D-77-30.

The objectives of this study at the mouth of the Columbia River were to identify and determine the significance of physical, chemical, and biological factors that govern the rate at which open-water dredged material disposal sites are colonized by benthic assemblages. In baseline investigations, the distribution, community structure, and seasonal constancy of these assemblages were related to the distribution of sediments and organic matter, the stability of sediments, and changes in sediment characteristics due to the deposition of fine-grained material from the Columbia River. The deposition of dredged material significantly increased diversity and evenness values and reduced the density of macrofauna. Of the 33 most abundant species, 11 species had significantly lower abundances at stations exposed to direct dredged material deposition. The effects of dredged material disposal on benthos were related to direct burial of benthos and changes in sediment characteristics and not increased turbidity from the disposal operation or introduction of pollutants or organic matter. Repopulation of benthos into the affected area was probably accomplished primarily by benthos burrowing up through the dredged material or benthos migrating into the area and, to a lesser extent, reproduction and recruitment of benthos from outside the area. There was very little evidence for transportation of benthos to the experimental disposal site via dredged material. For an evaluative summary and interpretation of all studies conducted at the field site, see abstract number 308.

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Aquatic disposal field investigations, Columbia River disposal site, Oregon. Appendix E: Demersal fish and decaped shellfish studies. Joseph T. Durkin, Sandy J. Lipovsky. Hammond, OR, National Marine Fisheries Service, November 1977. Technical Report D-77-30.

Information is provided on 51 finfish and 13 decapod shellfish found at five sites off the Columbia River mouth. The effects of a controlled sediment release by hopper dredges on these indigenous species were studied. Numerically important species were anchovy, smelt, sole, poachers, snailfish, shrimp, crab, tomcod, and sanddab. Nonparametric test indices of community diversity usually decreased at the experimental test site during and after sediment deposition. However, diversity indices subsequently recovered. Characteristics of dominant species are described including size range, food preference, and seasonal availability. Using data on dominant species, statistical tests indicated catch differences usually occurred between sites and between months; further, individuals at the test site were smaller. Tests were limited by small numbers of species and individuals taken at the test site during and after sediment deposition. Finfish food studies revealed preferential feeding habits where consumption of small organisms diminished and utilization of shrimp and anchovy increased. The experimental release of sediments was detectable by diversity indices. For an evaluative summary and interpretation of all studies conducted at the field site, see abstract number 308.

Ashtabula (Ohio) Field Study

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Aquatic disposal field investigations, Ashtabula River disposal site, Ohio. Evaluative summary. Robert A. Sweeney. Buffalo, NY, State University College at Buffalo, Great Lakes Laboratory, June 1978. Technical Report D-77-42 (NTIS No. AD-A055 865).

A summary of the physical, chemical, and biological studies conducted at the Ashtabula River (Ohio) confined disposal site to determine the effects of open-water disposal of dredged

material in this lacustrine environment of Lake Erie is presented. The data indicate that the impacts on the water column including the phytoplankton and zooplankton communities were short-lived. While the benthos as well as the chemical and physical nature of the sediments were altered, predisposal conditions generally were reestablished within a year after the release of the dredged material. Storm event related erosion of the dredged material appeared to be a major factor in the recovery of the area. There was no evidence of accelerated uptake of heavy metals by fish or benthos as a consequence of disposal. Harbor macroinvertebrates, transported with the dredged materials, did become established in the deposition area. With the exception of the latter, the observed impacts are similar to those noted in studies conducted to evaluate the impact of dredged materials on the marine environment. Appendices to this report discuss: (1) the planktonic communities, benthic assemblages, and fishery at the site; (2) the investigation of the hydraulic regime and physical nature of bottom sedimentation; and (3) the investigation of water-quality and sediment parameters. 46 references. (Author abstract modified)

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Aquatic disposal field investigations, Ashtabula River disposal site, Ohio. Appendix A: Planktonic communities, benthic assemblages, and fishery. Robert A. Sweeney. Buffalo, NY, State University College at Buffalo, Great Lakes Laboratory, July 1978. Technical Report D-77-42

An investigation to evaluate impacts of the release of dredged material on phytoplankton, zooplankton, benthic macroinvertebrates, and fish was conducted in Lake Erie off Ashtabula, Ohio. The pelagic biota (phytoplankton, zooplankton, and fish) along with primary productivity were only mildly impacted and recovery was relatively rapid. The benthic communities were altered with the decline of some species and introduction of new fauna transported from the dredged sites. Within a year species diversity had largely returned to pre-disposal levels. However, the community structures were slightly altered. These changes were similar to those noted in marine environments exposed to dredged material. For an evaluative summary and interpretation of all studies conducted at the field site, see abstract number 313.

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Aquatic disposal field investigations, Ashtabula River disposal site, Ohio. Appendix B: Investigation of the hydraulic regime and physical nature of bottom sedimentation. L. J. Danek, G. R. Alther, P. P. Baily, R. G. Johnson, F. de Libero, J. F. Yohn, F. T. Lovorn. Northbrook, IL, Nalco Environmental Sciences, December 1977. Technical Report D-77-42

An investigation of the hydraulic regime and physical nature of bottom sedimentation was conducted in Lake Erie near the Ashtabula disposal site. The field sampling phase of the program included detailed monitoring of physical parameters before, during, and after disposal operations at the disposal sites and at reference stations. The various hydraulic, sedimentologic, and limnologic data gathered from the site and analyzed include bathymetry and sub-bottom profiles, current speed and direction, temperature, and transmissivity within the water column; wave characteristics, bottom sediment characteristics and distribution, water levels of Lake Erie, and flow rate and suspended sediment load of the Ashtabula River. The study indicated that the dredged material disposal operations had little effect on the physical nature of the area. The localized increases in temperature, turbidity, and currents resulting from the descending material were quite transient and the conditions generally returned to ambient within an hour. The resulting sediment piles on the lake bottom were less than 0.5 m thick, and were subject to erosion from currents and waves. The currents were the main cause of erosion as most of the wave energy did not penetrate to the bottom. Most of the sediment erosion and subsequent transport occcurred during storms when current speeds and wave heights were greatest. Analysis of bottom sediment cores revealed that the dredged material was difficult to distinguish from the original lake bottom, indicating that the disposal operation produced only minimal changes in the physical nature of the sediments in the area. For an evaluative summary and interpretation of all studies conducted at the field site, see abstract number 313.

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Aquatic disposal field investigations, Ashtabula River disposal site, Ohio. Appendix C: Investigation of water-quality and sediment parameters. Robert K. Wyeth, Robert A. Sweeney. Buffalo, NY, State University College at Buffalo, Great Lakes Laboratory, July 1978. Technical Report D-77-42

An investigation to evaluate impacts of the release of dredged material on chemical aspects of the aquatic and benthic environments was conducted in Lake Erie off Ashtabula, Ohio. The impact on the water column was short lived with a return to ambient pre-disposal conditions for most parameters within 90 minutes after release of dredged material. Impacts on interstitial water generally dissipated in less than 90 days after disposal. The benthic environment was the most affected in terms of chemical changes. A return of pre-disposal conditions did occur within a year primarily due to erosion. There was no evidence of heavy metals accumulations by either benthos or fish as a consequence of disposal of dredged material. A Standard Elutriate Test preparation time dependency study also was done. This investigation resulted in some suggested changes for improving reliability. For an evaluative summary and interpretation of all studies conducted at the field site, see abstract number 313.

Galveston (Texas) Field Study

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Aquatic disposal field investigations, Galveston, Texas, offshore disposal site. Evaluative summary. Thomas D. Wright, David B. Mathis, James M. Brannon. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, May 1978. Technical Report D-77-20 (NTIS No. AD-A061 844).

A summary of the results of a comprehensive investigation of the physical (sedimentological), chemical, and biological impacts of dredged material open-water disposal off the shore of Galveston, Texas, conducted in 1975 and 1976, is presented. The study involved detailed monitoring of the disposal of small amounts of highly contaminated material dredged from the Texas City Turning Basin, as well as clean and sandy silt from the Galveston Bay Channel. Results of this research will be useful on a regional basis for evaluating the possible environmental impacts of open-water disposal in shallow Gulf of Mexico environments. Appendices to this report (abstracted below) describe: (1) the investigation of the hydraulic regime and physical nature of sedimentation; (2) the investigation of water-quality parameters and physicochemical parameters; and (3) the investigation of the effects of dredging and dredged material disposal on offshore biota. 19 references.

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Aquatic disposal field investigations, Galveston, Texas, offshore disposal site. Appendix A: Investigation of the hydraulic regime and physical nature of sedimentation. E. L. Estes, R. J. Scrudato. College Station, TX, Texas A&M University, Moody College, Department of Marine Sciences, December 1977. Technical Report D-77-20.

This report presents the results of an investigation of the geological processes of deposition, erosion, and transport of dredged material within the area of the Galveston offshore dredged material disposal site. This study involved two major phases: a pilot study designed to rapidly survey the site and environs, and an experimental study to delineate natural changes in the physical and geological characteristics of the study area after disposal had occurred. The latter study involved the monitoring of dredged material disposal at selected locations to determine the physical geological processes active. Control sites were also monitored for comparison. Hydrographic data were collected to delineate current and wave effects within the site, and flume experiments were conducted to determine the hydrodynamic characteristics of dredged material placed in the area. Comparisons are made between sediment and carbonate concentrations and bathymetric differences evident from data collected during the pilot and post-disposal phases of the study. The differences determined are discussed in light of the hydraulic regime present. Estimates of current velocities required to redistribute bottom sediments are based on comparisons between flume experiment studies and on-site current meter data. Available data indicate that dredged material has been eroded from the shallow water portion of the site and has been transported in a downcoast-offshore direction; little erosion was noted in the deeper, offshore disposal sites. For an evaluative summary and interpretation of all studies conducted at the field site, see abstract number 317.

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Aquatic disposal field investigations, Galveston, Texas, offshore disposal site. Appendix B: Investigation of water-quality parameters and physicochemical parameters. G. Fred Lee, Pinaki Bandyopadhyay, Jeannie Butler, David H. Horner, R. Anne Jones, Jose M. Lopez, George M. Mariani, Cameron McDonald, Michael J. Nicar, Marvin D. Piwoni, Farida Y. Saleh. Richardson, TX, University of Texas at Dallas, Center for Environmental Studies, December 1977. Technical Report D-77-20.

A study was conducted on the environmental impact of the chemical contaminants present in dredged sediments which were dumped at the site in the Gulf of Mexico. A series of predisposal surveys was conducted to establish background data on the characteristics of the disposal site water column and sediments. Nine dumps of dredged sediments were monitored, with sampling sites generally located 100 to 200 meters downcurrent from the dump sites. Post-disposal surveys were conducted to determine if the chemical contaminants present in the disposed sediments had residual effects on water quality. The heavy metals, copper, cadmium, mercury, lead, nickel, zinc, chromium, iron, manganese, and arsenic, aquatic plant nutrients, such as nitrogen and phosphorus compounds, toxicants, and other parameters, such as oxygen demand and sulfide, were monitored before, during, and after disposal. Each disposal operation resulted in a turbid plume containing a small amount of finely divided dredged sediment which moved from the disposal site with the current. This turbid plume was rapidly dissipated or transported from the sampling area. No residual effects were found a few hours following cessation of disposal. There was release of some contaminants, such as ammonium and manganese, associated with the turbid plume. The contaminant concentrations found were generally below those known to cause water quality problems considering the time and concentration relationships existing for organisms inhabiting the water column at or near the disposal site. Most contaminants studied were not released with passage of the turbid plume. Sediment studies showed that disposal of Galveston Bay Entrance Channel sediments did not significantly change the overall chemical characteristics of the sediments. Overall, the study has shown that open-water disposal of these sediments would not be expected to have a significant adverse effect on water quality in the Galveston Bay Entrance Channel offshore disposal site water column. For an evaluative summary and interpretation of all studies conducted at the field site, see abstract number 317.

material dumped during the study did not have a lasting detrimental effect on the demersal fish and shellfish populations at the disposal site. For an evaluative summary and interpretation of all studies conducted at the field site, see abstract number 320.

Duwamish (Washington) Field Study

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Aquatic disposal field investigations, Duwamish Waterway Disposal Site, Puget Sound, Washington. Evaluative Summary. Final report. Henry E. Tatem, Jeffrey H. Johnson. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, June 1978. Technical Report D-77-24 (NTIS No. AD-A058 445).

An overview of a multidisciplinary study of the physical, chemical, and biological effects of disposal of contaminated dredged material from the Duwamish River on a deepwater disposal site located in Elliott Bay, Puget Sound (Washington), is presented. A total of 114,250m³ of contaminated dredged material was involved in the disposal operation. Appendices to this report (abstracted below) discuss: (1) the effects of dredged material disposal on demersal fish and shellfish in Elliott Bay; (2) the role of PCB-contaminated sediment in the accumulation of PCBs by marine animals; (3) the effects of dredged material disposal on the concentration of mercury and chromium in several species of marine animals; (4) chemical and physical analyses of water and sediment in relation to disposal of dredged material; (5) release and distribution of PCBs induced by open-water dredge disposal activities; (6) recolonization of benthic macrofauna over a deepwater disposal site; and (7) resulting benthic community structural changes. 26 references.

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Aquatic disposal field investigations, Duwamish Waterway disposal site, Puget Sound, Washington. Appendix A: Effects of dredged material disposal on demersal fish and shellfish in Elliott Bay, Seattle, Washington. John R. Hughes, David A. Misitano, Warren E. Ames, George F. Slusser. Mukilteo, WA, National Marine Fisheries Service, Northwest and Alaska Fisheries Center, May 1978. Technical Report D-77-24.

A cooperative research program was conducted in Elliott Bay near Seattle, Washington, by the National Marine Fisheries Service of the National Oceanic and Atmospheric Administration to determine the effects of dredged material disposal on demersal fish and shellfish at the Duwamish Waterway disposal site. Catches of both fish and shellfish were inconsistent at the disposal and reference sites with respect to both numbers and species, indicating a seasonal fluctuation in both abundance and composition. The experimental design and inherent differences among the sampling sites made it difficult to determine whether the catch differences were attributable to effects of the dredged material disposal or simply manifestations of population fluctuations due to migratory behavior patterns. It was concluded that the quantity of dredged

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Aquatic disposal field investigations, Duwamish Waterway disposal site, Puget Sound, Washington. Appendix B: Role of disposal of PCB-contaminated sediment in the accumulation of PCB's by marine animals. Virginia F. Stout, Laura G. Lewis. Seattle, WA, National Marine Fisheries Service, Northwest and Alaska Fisheries Center, November 1977. Technical Report D-77-24.

This report describes studies concerning the possible transfer to marine animals of polychlorinated biphenyls (PCB's) as a result of the open-water disposal of PCB-laden dredged material. The PCB content of indigenous animals, English sole (*Parophrys vetulus*) and Alaska and Oregon pink shrimp (*Pandalus borealis* and *P. jordani*), and animals caged at the site, spot shrimp (*P. platyceros*), sea cucumber (*Parastichopus californicus*), and mussel (*Mytilus edulis*) was determined. It was not possible to ascertain whether or not marine animals concentrate PCB's as the result of deposition of PCB-laden dredged material. The small increase in PCB level observed in mussels may have been related to the flux of PCB's resulting from the disposal operation. Alternatively, it may be issued from the PCB burden normally carried downstream by the Duwamish River. These data indicate that no obvious changes have occurred in the PCB levels in marine animals in Elliott Bay as the result of depositing PCB-laden dredged material at the experimental site. For an evaluative summary and interpretation of all studies conducted at the field site, see abstract number 320.

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Aquatic disposal field investigations, Duwamish Waterway disposal site, Puget Sound, Washington. Appendix C: Effects of dredged material disposal on the concentration of mercury and chromium in several species of marine animals. Fuad M. Teeny, Alice S. Hall. Seattle, WA, National Marine Fisheries Service, Northwest and Alaska Fisheries Center, November 1977. Technical Report D-77-24.

Specimens of five species of marine organisms indigenous to Puget Sound were collected over a period of nine months for mercury and chromium analysis. The specimens were collected from two evironmentally similar sites in Elliott Bay, the disposal site for 'polluted' dredged material from the Duwamish Waterway and a reference or control site. Mercury and chromium concentrations in English sole (*Parophrys vetulus*), Alaska and Oregon pink shrimp (*Pandalus borealis* and *P. jordani*), spot shrimp (*Pandalus platyceros*), sea cucumber (*Parastichopus californicus*), and mussel (*Mytilus edulis*) were not significantly different between the two sites. In all samples, the levels of mercury and chromium were low and did not

exceed 0.10 ppm for mercury and 0.91 ppm for chromium. These data suggest that the disposal operation had no apparent effect upon the mercury and chromium concentrations in the five species of organisms studied. For an evaluative summary and interpretation of all studies conducted at the field site, see abstract number 320.

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Aquatic disposal field investigations, Duwamish Waterway disposal site, Puget Sound, Washington. Appendix D: Chemical and physical analyses of water and sediment in relation to disposal of dredged material in Elliott Bay. Volume I: February-June 1976. D. J. Baumgartner, D. W. Schults, J. B. Carkin. Corvallis, OR, Environmental Protection Agency, Corvallis Environmental Research Laboratory, Marine and Freshwater Ecology Branch, June 1978. Technical Report D-77-24.

Appendix D, Volume I, describes the chemical effects of the deposition of over 100,000 m^3 of dredged Duwamish River sediment. Results obtained by monitoring physical and chemical parameters in the water column and sediment were evaluated to gain insight regarding the effects of dredged material disposal in open estuarine waters. Parameters monitored in the water column included: suspended solids, pH, NH_3-N, NO_2 + NO_3, ortho PO_4-P, Cr, Hg, As, and Mn. Parameters monitored in the sediment included: moisture content, Eh, organic C, NH_3-N, ortho PO_4-P, alkaline soluble S^{--}, bulk and interstitial Cr, As, Mn, Hg, and particle size distribution. The monitoring program was conducted before, during, and at several intervals after dumping to determine the temporal and spatial impact associated with the dumping activity. Data obtained during the disposal operation showed that the dredged material fell rapidly to the seabed when dischanged from the barge. Manganese, suspended solids, and ammonia were found to be elevated above ambient in the water column at the near-bottom sampling point. Long-term water quality monitoring showed only a small increase in suspended solids concentration near the bottom. Long-term sampling of the sediments showed the presence of river material at the disposal site, as evidenced by particle size distribution and concentration of certain chemical constituents which persisted through three months of post-disposal monitoring. For an evaluative summary and interpretation of all studies conducted at the field site, see abstract number 320.

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Aquatic disposal field investigations, Duwamish Waterway disposal site, Puget Sound, Washington. Appendix D: Chemical and physical analyses of water and sediment in relation to disposal of dredged material in Elliott Bay. Volume II: September-December 1976. S. Sugai, W. R. Schell, A. Nevissi, S. Olsen, D. Huntamer. Seattle, WA, University of Washington, College of Fisheries, Laboratory of Radiation Ecology, June 1978. Technical Report D-77-24.

This report presents results obtained in a study conducted to evaluate the extent and duration of changes in chemical characteristics of Elliott Bay, Washington, six and nine months after disposal of dredged materials from the Duwamish River. The seawater, sediment, and interstitial water were analyzed for the following chemical parameters: (1) Seawaters Suspended solids, arsenic, manganese, mercury, reactive silicate, inorganic phosphate, nitrate, and ammonia. (2) Sediment: free and total (acid soluble) sulfide, manganese, chromium, arsenic, mercury, and particle size. (3) Interstitial water: arsenic, manganese, reactive silicate, ammonia, and inorganic phosphate. Temporal, depth, and spatial changes in concentrations of chemical variables were evaluated at disposal and reference sites. The results of analyses showed only minimal changes in trace metal concentrations in the water column above the disposal site, but lower Eh and pH values in the sediments than at the reference site. The manganese, inorganic phosphate, and ammonia concentration values were greater in interstitial waters at the disposal site than at the reference site. For an evaluative summary and interpretation of all studies conducted at the field site, see abstract number 320.

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Aquatic disposal field investigations, Duwamish Waterway disposal site, Puget Sound, Washington. Appendix E: Release and distribution of polychlorinated biphenyls induced by open-water dredge disposal activities. Spyros P. Pavlou, Robert N. Dexter, Wilson Horn, Andrew Hafferty, Katherine A. Krogslund. Seattle, WA, University of Washington, Department of Oceanography, January 1978. Technical Report D-77-24.

This report presents a detailed discussion of the results obtained in a study conducted to evaluate the release of polychlorinated biphenyls (PCB's) during open-water disposal of contaminated dredged material in Elliott Bay, Puget Sound, Washington. The specific information provided consists of the following: (1) A documentation of the release of PCB's from the dredged material to the water column during and after disposal of contaminated sediments from the Duwamish River. (2) An evaluation of the spatial and temporal trends in PCB levels at the disposal site and its immediate vicinity. (3) An examination of the dependence of PCB residues measured in water, suspended particulate matter (SPM), and sediments on physical and chemical variables (appropriate to each marine phase examined) which might affect the accumulation and release characteristics of these chemicals from the disposed material. (4) An assessment of the change in the distribution characteristics of PCB's in the impact zone as compared to the prevailing ambient conditions in the area prior to disposal. Appendices A-E to this volume present the raw data tables, descriptions of material and techniques, along with the computer program used for PCB data reduction and a sample input and output. For an evaluative summary and interpretation of all studies conducted at the field site, see abstract number 320.

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Aquatic disposal field investigations, Duwamish Waterway disposal site, Puget Sound, Washington. Appendix G: Benthic community structural changes resulting from dredged material disposal, Elliott Bay disposal site. C. Rex Bingham. Vicksburg, MS, U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, August 1978. Technical Report D-77-24.

Benthic community changes resulting from the open-water disposal of 114,350 m^3 of Duwamish River dredged material at the Elliott Bay, Puget Sound disposal site are described. Analyses were performed on macrofaunal density, species composition, biomass, biomass/individual, frequency of occurrence, and species diversity, at several taxonomic levels for one pre-disposal sampling and five post-disposal samplings at 10 days, and 1, 3, 6, and 9 months after disposal. Total macrofaunal densities at the disposal site showed large decreases 10 days after disposal that were unmatched by decreases at the reference sites. Disposal site total macrofaunal density gradually increased thereafter through 6 months after disposal, then decreased slightly at 9 months after disposal. The most abrupt increase occurred at 3 months. Disposal site macrofaunal densities never returned to their pre-disposal level nor to concurrent levels at the reference sites. Total number of species showed large decreases at 10 days and 1 month after disposal, a considerable increase at 3 months, and a leveling off for the remainder of the study. Species diversity indices decreased at 10 days and 1 month after disposal at the disposal site and increased thereafter for the remainder of the study. At 9 months the disposal site species diversity index exceeded both its pre-disposal value and concurrent values at the reference sites. Comparison of corner, side, and central disposal site stations and the two reference sites showed that the effects of dredged material disposal upon the previously discussed parameters were graded within the disposal site with central stations receiving the greatest negative impact. Most individual species showed seasonal trends (both graphically and statistically) at the reference sites and the corner disposal site stations, indicating that rate of benthic macrofaunal recovery from dredged material disposal may be affected by seasonal parameters. Therefore, timing of dredged material disposal on similar sites may be important in reducing the severity of impact on the benthic macrofauna. For an evaluative summary and interpretation of all studies conducted at the field site, see abstract number 320.

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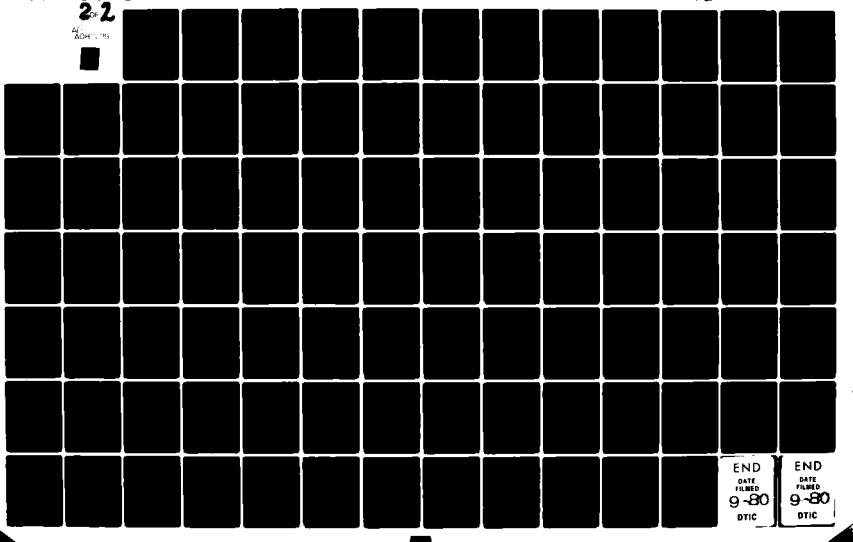

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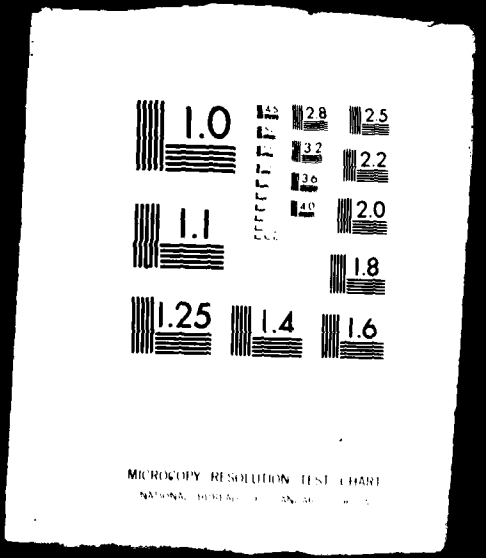

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